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The Manufacture of Rotating-Projectile Bands by Centrifugal Casting.

By Louis J. Josten.

Fourteen and sixteen-inch cupro-nickel rotating-projectile bands are now being manufactured at the works of the George C. Clark Metal Products Company, Detroit, Michigan, for the United States Navy Department by the centrifugal casting machine process in a very successful and satisfactory manner. This process is patented by Mr. George C. Clark (President of the company) in the United States and Foreign Countries. The success of this process is due to the efforts of Mr. Clark, who carried on experiments for over two years before it was pronounced practical. The making of cupro-nickel bands by the centrifugal casting process is novel in many respects, requiring keen judgment and practical knowledge. This knowledge must be gained by actual experience in the process. Details of minor importance in other lines of manufacture become items of major consideration in this process; therefore individual operations are done in a scientific way, all hit-and-miss methods being avoided.

The soundness of a casting produced by this process is far superior to one made in a sand mould, as there is no sand to wash away during pouring, causing sand holes or gases which cannot escape, causing blow holes. The centrifugal force acting upon the band during solidification has the same effect greatly intensified as a "head" placed upon a sand casting, which produces a gravity force. In this process it is practically impossible for porosity to occur if proper care is exercised. If any dirt or impurities were given off during melting and should happen to get past the skimmer in the pouring operation one would know in advance where to look for such impurities in the centrifugal-cast band. The performance of the machine is like that of a cream separator, separating the light from the heavier elements, and as all of the impurities in the copper are lighter than the copper they must assume the lesser radii. This actually happens, and all of the impurities are to be found on the inside periphery of the band and are removed in the machining of the band. Numberless samples tested show that no such imperfections are present; on the contrary, all tests have shown the complete absence of such impurities.

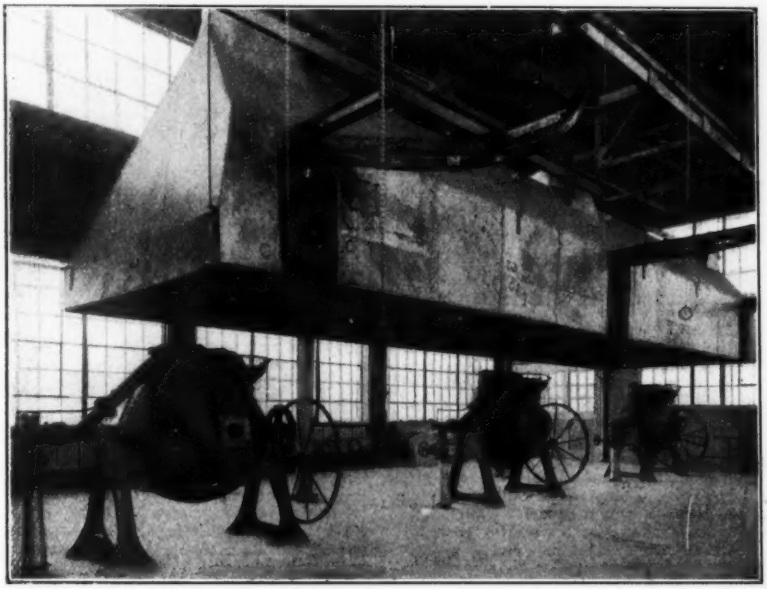

FIG. 1.—VIEW OF FURNACE ROOM SHOWING THREE HAWLEY DOWN-DRAFT FURNACES.

The plant of the George C. Clark Metal Products Company consists of a one-storey building, 110

ft. long by 50 ft. wide, which is partitioned off so that 2,200 sq. ft. of area is allotted to the furnace room and the remainder for the casting and machining room. The small amount of floor space required is one of the principal advantages. Another feature worthy of mention is the cleanliness of all departments of the plant. There is no foundry-sand or dust, no sandy castings to knock off the edges of the machining tools, and no sandy turnings to remelt. On the outside of the plant is an underground reservoir, which holds 20,000 gallons of oil for use in the furnaces. A railroad siding is also provided for the loading of bands for shipment.

Melting.

Fig. 1 shows a view of the furnace room installed with three Hawley Down-Draft Furnaces of 3,000 lbs. capacity each. The air is furnished by three P.H. and F.M. Roots Company rotary pressure blowers. Ordinary methods of melting are all that are necessary to melt the mixture, which is composed of 97½ to 98 per cent. copper and 2 to 2½ per cent. nickel. Nothing but high-grade ingot copper and the turnings from the bands are allowed, as the specifications call for ingot copper of not less than 99.9 per cent. purity. The nickel used is of the best and purest grade obtainable. The tapping temperature is about 2,300 degs. Fah., so as to allow for a casting temperature of 2,150 degs. The correct pitch of the metal is tested from time to time before the metal is tapped by means of buttons. Care must be exercised to see that the oil that is used in the furnaces is of a proper analysis as to its sulphur content. The three furnaces are melting about 20,000 lbs. a day. The ladle receiving the metal from the furnace is of a capacity sufficient to pour three bands. It is hauled to the casting room by means of an overhead trolley system. Extra precaution is taken that the metal does not oxidise on its way to the casting room.

Handling of the metal is one of the most important features connected with this process. Positive methods must be employed that will permit the band to be cast at the most desirable temperature. This is a very important point, for if the casting temperature is not correct the physical tests will fail, rejecting the entire heat. It therefore becomes important that a sufficient number of machines be in operation to permit of the removal of the metal from the furnace in the shortest time possible, after it has been brought up to the proper pitch and temperature.

Centrifugal-Casting Machine.

Fig. 2 shows one row of casting machines, there being two rows of three machines each. The principal parts of the machine are the die and die-holder, the movable spout and the metal-pouring attachment. The die and holder are driven by a shaft, to which is attached a foot-lever brake controlling the speed of the die and holder. The speed of the machine varies with the size of the die used, being about 1,050 r.p.m. for the 14-in. band. The holder is made of plain carbon-steel, while the die or liner is a forging, specially heat-treated, and held in place by means of six set-screws. A hinged cover-plate of the same diameter as the holder, and having an opening large enough to accommodate the pouring spout, is made to open and close on one side of the die and holder. This cover-plate prevents the metal from running out of the die during casting. After the band is cast and has been cooled sufficiently this cover-plate is unscrewed and the band removed from the machine. The life of a liner is such that about 250 bands can be cast before it is burned out and has to be replaced.

All revolving parts of the casting machine are made in absolute balance. This is most important, and one can readily see what influence any unbalancing would have upon the product. The two masses in high rotative velocity would be assuming two radii of gyration, causing the mass of metal to change its relation with the periphery of the liner while still in a molten state, thus causing uncontrolled contractions in the castings. The pouring spout and metal-pouring attachment is made to move upon a V slide. The position of this spout is most important and should be such that it delivers the metal to the periphery of the liner without excessive splashing. This spout is not permanently attached, but is made to raise and lower for the purpose of movement in or out of the die. The spout is supported near the pouring lip by a rod. Trunnion bearings made of strip steel and placed in a line with the spout are constructed on each machine to accommodate the tilting of the pouring ladle.

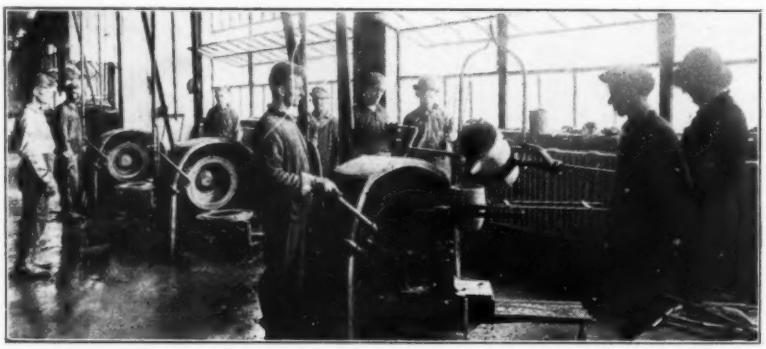

FIG. 2.—ROW OF CASTING-MACHINES.

Each casting machine is equipped with an air hose to clean off all particles that may adhere to the die and cover-plate after casting. A water pipe is conveniently placed so that the pipe may be adjusted by hand to supply water to the die during casting for annealing purposes or bent back out of the way when the machine is not in operation. A drain pipe carries the water away from each machine. A sheet-iron shield covers the die and holder to prevent excessive splashing of water or metal.

Casting.

In preparing the machine for casting, the cover-plate on the side of the die and holder is unscrewed and let down. The air hose is then used to remove any foreign substance that may be adhering to the die or inside of the cover-plate. The die and the inside face of the cover-plate are coated with plumbago, and after the cover-plate is screwed in place, powdered talc is sifted very lightly on the inside of the die to keep

the metal from sticking. The pouring spout is also coated with plumbago. The machine is now made to revolve, and the spout is moved forward so as to deliver the metal to the die. The metal is brought from the furnace room in a ladle of three times the capacity of the small crucible shown on the machine in Fig. 2. The amount of metal poured into the small crucible on the machine is sufficient, as shown by experiments, to allow the band to be cleaned up in machining. The metal is now ready to pour. This is done by tilting the small crucible on the machine so that the metal will flow through the small spout into the die. While the machine is still in motion the spout and crucible, which move upon a V slide, are pulled back out of the way. When the band shows the desired colour for annealing a stream of water is turned on the band through a pipe. This pipe is adjustable by hand so as to place it in the correct position. This feature saves considerable time and expense, as the band is annealed by its own casting heat. After the band has sufficiently solidified and has received its proper annealing the water pipe is taken back out of the way so the cover-plate can be unscrewed and let down to allow the band being removed from the die. The band is then weighed to see that there is sufficient metal to allow of the band cleaning up. The casting date is stamped upon each band, for instance 7-2-3, which denotes that it is the third heat of July 2. The date of casting and heat-number are put on each band, so that if the heat failed either as to chemical analysis or physical tests as required by the specifications it could be identified and rejected. After the band is cast it is necessary to keep the lip of the pouring spout clean, as a certain amount of metal clings to its sides and has to be removed by hand with a chisel.

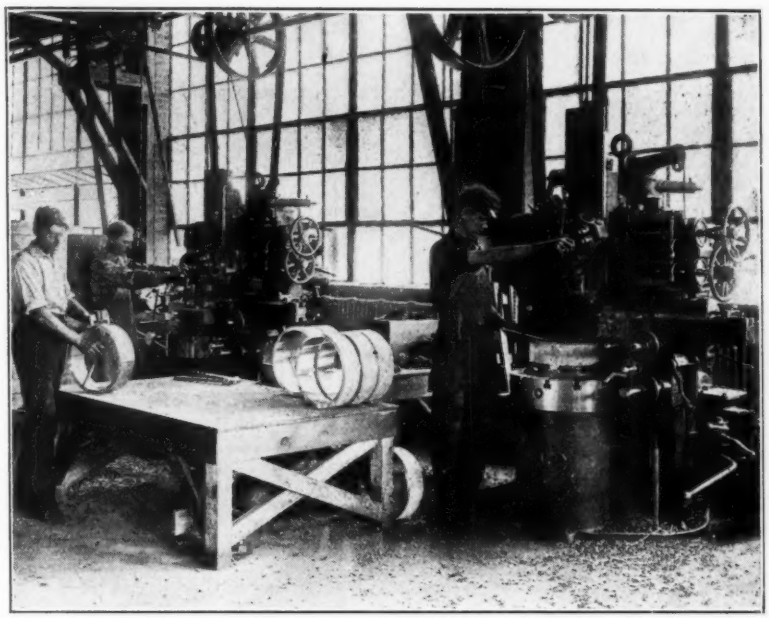

FIG. 3.—TWO BULLARDS IN OPERATION FOR MACHINING BOTH INSIDE AND OUTSIDE OF BANDS.

Machining.

Fig. 3 shows two Bullards in operation, one for machining the inside of the bands, the other the outside of the bands. There are only three machines necessary to completely machine the bands, namely, two Bullard vertical turret lathes and an ordinary engine lathe. The first operation in the machining of the band is done by placing the band in the engine lathe to remove the large fin which forms on the inside of the band during casting shown in the rough band in the right foreground of Fig. 4. The second operation is set up on the first Bullard for machining the inside of the band and the top face of the band. The fixture made to hold the band for this operation consists of three steel castings which are individually screwed down to the chuck of the machine, so as to move universally when tightening or loosening one of the chuck screws. The band now moves off to the second Bullard, which is set up for machining the outside diameter and the reverse face of hand. On this set-up the band is held in place by an expansion toggle-joint chuck made in three parts. The sharp edges of the band are rounded off. The band, now being completely machined, is moved on to the inspection bench to inspect for surface defects and check up for gauge dimensions. The tolerances allowed by the Government in machining are very liberal, being twenty-five to thirty thousandths in most cases. A small auxiliary machine shop is operated in one corner of the building for machining the dies, holders and tests.

Testing and Inspection.

Two physical tests are required to pass a heat of bands, one being taken from the beginning of the heat, the other at the end of the heat. The test pieces are machined to a size designated in the specifications, namely, 1½ in. × ⅜ in. thick. The elongation is taken over a 3-in. length. The physical requirements are as follows :—Tensile strength, 30,000 lbs., minimum; elongation, 30 per cent., minimum; reduction of area, 35 per cent., minimum. In the selection of test pieces this process is at a disadvantage over other methods, as there is no way of obtaining test pieces without destroying a good machined band, as each test selected has to go through the same process of manufacture and heat-treatment as the bands that it represents in the

lot. The band from which a test piece is to be cut out is first taken to an arbor press and flattened down to an opening of about 5 in. Then a piece of sufficient length for a test piece is cut from the flattened side in a high-speed cut-off machine. The tests are then finished to the correct size and shape in a shaper. The remarkable ductility of rotating bands made by the Clark process is greatly in favour of this method of manufacture, and a large number of tests for elongation and reduction of area having averaged over 45 per cent. above the Navy requirements.

Cast Iron, Graphite and Pearlite.

Practically all cast iron generally used in modern engineering business are of the Graphite and Pearlite series. This quality would probably contain a total of 4 per cent. carbon, with an approximate amount, from 2 per cent. to 3.5 per cent. of graphite, the remainder being carbon in combination as cementite. All grey iron castings for machinery, piping, columns, etc., are of the above series. Generally speaking, the greater the need for softness to facilitate machining, and malleability to resist shocks or ill-treatment, the smaller should be the combined carbon or cementite and the larger that of ferrite.

The ironfounder often looks at the other side of the question. The less carbon present in the form of cementite, the more must be present in the form of graphite, if the total carbon is about constant, which is usually the case. Hence, the greater the softness needed, the more graphite is usually present; therefore the founder may regard graphite as the source of softness.

But this is simply the opposite view of the same fact, and the whole subject may be made much clearer by another point of view, and recognise that the softness, etc., may be obtained by having the softer ferrite and graphite in place of the harder cementite. Without going deeper into this view, another definition of grey iron would be a matrix of steel, or white cast iron, as the case may be, in which is scattered unmetallic flakes of graphite as a foreign body.

As this conception of matrix plus graphite is essential, we can compare it practically with the greyness of the fracture of cast iron. Assuming a total of 4 per cent. carbon, 3 per cent. by weight, or about 10 per cent. by volume, would be in graphite flakes, and forming a scattered skeleton throughout the mass. When the iron is broken the fracture would follow the lines of least resistance and travel along the flakes of graphite instead of through the metallic matrix, and the face of the cleavage would show mainly graphite. This loose graphite may be brushed off with a wire brush, exposing the whiteness of the face-metal. The presence of graphite scattered in this form throughout the mass would both weaken and embrittle the casting.

It is a familiar fact that the presence of silicon favours the formation of graphite. All carbon may be regarded as combined with the metal while in a molten condition; otherwise it would rise to the surface.

Of this variable amount, part will turn into graphite during cooling, the proportion increasing with the slowness of cooling, and also with the silicon contents, at least until this latter reach, say, 75 per cent., but diminishing with the sulphur contents, and under certain conditions with the manganese. In foundry experience, iron, either silicon-free or rich in sulphur or manganese, is apt to be "white," its fracture indicating little or no graphite. Iron containing at least a moderate amount of silicon, especially free from excessive amounts of sulphur and manganese, is usually grey.

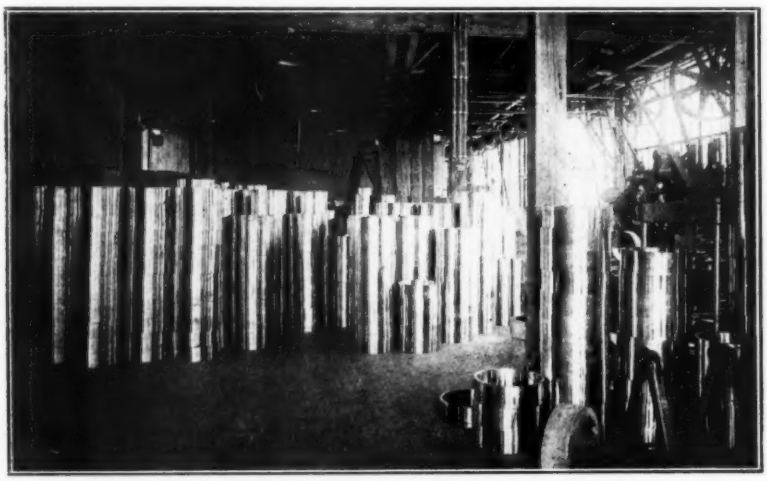

FIG. 4.—ANOTHER VIEW OF MACHINE ROOM SHOWING FINISHED BANDS.

This effect of silicon and sulphur and that of cooling in iron foundry practice are set off against each other in order to obtain the required amount of graphite. Thus, if the percentage of sulphur is too high, the silicon may be increased; or if the castings cool rapidly, due to thinness or green sand moulds, or even in iron moulds instead of "dry" moulds, then, since the rapid cooling would tend to restrict the formation of graphite, the percentage of silicon should be increased to stimulate the formation of graphite. Crushed high-grade silicon may be obtained containing 75 per cent. silicon. If added in the cupola with the charge, it should be in pieces the size of an egg, but if added to the ladle it should be crushed. A varying amount of silicon is lost in the cupola.

We have received the February issue of the "Industrial League Journal," which contains a review of the past year, together with reports of speeches by Mr. Maurice G. Liverman, Dr. Russell Wells, Lord Emmott, and others.

The Grid and its Uses.

By Joseph Horner.

The grid, when used as the internal skeleton of a core or a portion of a mould, has many forms. It may resemble a grille, with reticulated bars, or it may be a plain plate, or a bar, bristling with rods, a kind of vertebrate skeleton. Its almost infinite variations in form are due to the fact that, more than any other piece of moulder's tackle, it has to be made very closely to the outlines of the core, or portion of mould which it has to sustain. Whether of large or small dimensions, it must be but a little smaller than the mass which it carries. If otherwise, the portions of sand that were insufficiently supported would flake off. It is also necessary that a grid should be rigid enough to carry its mass of sand without springing, which would result in fractures of the sand. In this respect the principles involved are similar to those involved in the construction of a moulding flask and a core bar. On the other hand, a grid should be made as light as is consistent with strength and rigidity, in order to lessen the dead weight to be handled. This is generally secured by the combination of a rigid cast-iron, grille-like frame, with ribs of wrought-iron rods when necessary. Further, a section of core or mould must be lifted and carried, and often secured in place through its grid. Eyes, therefore, are cast in to serve one or both these functions. Lastly, many grids have to be broken up within their castings before they can be extracted. This contingency has to be considered and provided for, otherwise the operation of breaking up a too-strong and heavy grid within its casting may also damage the casting. In this feature they resemble the core plates fixed on

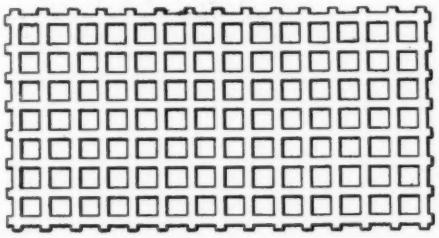

Fig. 1.

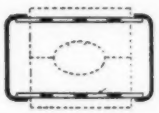

Fig. 3.

Fig. 2.

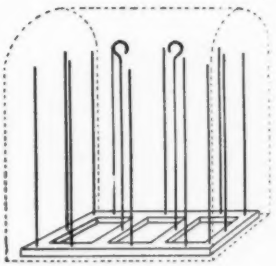

Fig. 4.

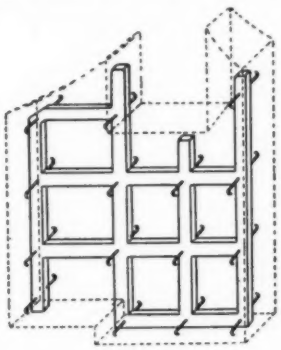

Fig. 5.

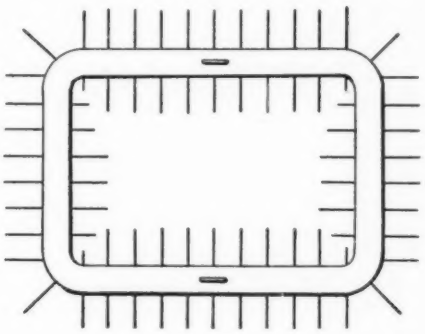

Fig. 6.

bars, which resemble grids in that they fulfil identical functions, though they are not usually classed as such. Moreover, since the function of the grid is the support of sand, the same general methods which are adopted

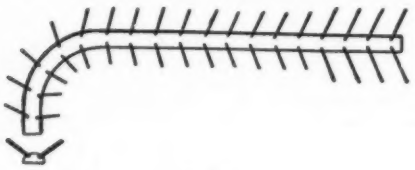

FIG. 7.

in moulds to secure its adhesion are practised. Loose rods are inserted, and nails, and lifters in some cases, and gaggers, and also swabbing with clay wash. In the fulfilment of these varied conditions lies the export for the sand. It is more difficult to ensure coherence of the sand in cores than in moulds, because a mould is enclosed in a box, while a core can have no external support. Whatever is done in this way must be from within—an endo-skeleton. Very small cores are sufficiently coherent to withstand the pressure of metal by virtue of the binding agents mixed with the sand. Much more attention has been given to the subject of binders of late years than formerly, largely on account of the fact that the automobile industry has demanded very narrow and many-curved cores for water jackets, etc. Some small cores are made without stiffening wires. But all cores of large or even of very moderate dimensions must have stiffening irons, rods, nails, or grids rammed within the sand. Without these aids the cores would bend, become distorted, or fracture, either when drying or during insertion in the mould, or under the pressure of the liquid metal. Core sands, though dried, are still fragile, and must be carefully handled, but only by

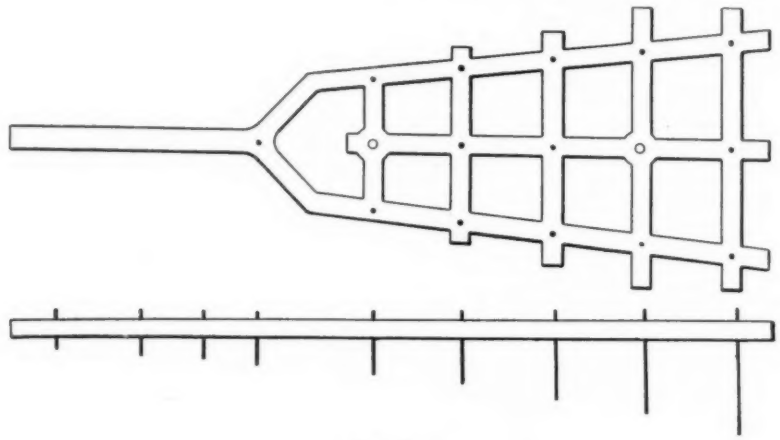

FIG. 8.

planation of the numerous forms of grids. In order to fulfil the functions of skeletons, their outlines and details are as varied as those of the cores and moulds that they reinforce.

Fig. 1 shows the standard pattern grid which is stored in foundries in several sizes of mesh, coarser and finer, and in several convenient dimensions, square and oblong in form. It is made of wood. From it plain grids of all dimensions and outlines are moulded. If the grids are of sizes larger than the pattern, they are made by repeating the mould in duplicate, the whole or a portion of the pattern being repeated side by side. These moulds are always cast open, i.e., without a top. A bed is first levelled with winding strips and spirit level, and the pattern is laid on it and rammed. Irregular outlines are formed by stopping-off. All ordinary grids for cores of generally rectangular outlines can be moulded from patterns such as these. An example is given in Fig. 2, being that for the half-thickness of a fly-wheel arm-core, the outline of which is dotted in. The horns shown standing out from the sides of the grid are required for clamping the half-cores together, as seen in Fig. 3.

Cores of plain forms, and of dried sand, when not too deep, can be carried on grids of this kind, even when the bounding edges are perpendicular. But very deep cores, and those of green sand, though shallow, require something in addition. The device of rodding is then adopted, as is done in green-sand moulds. Cores, equally with moulds, must have adequate support for the sand. It is more difficult to ensure coherence of the sand in cores than in moulds, because a mould is enclosed in a box, while a core can have no external support. Whatever is done in this way must be from within—an endo-skeleton. Very small cores are sufficiently coherent to withstand the pressure of metal by virtue of the binding agents mixed with the sand. Much more attention has been given to the subject of binders of late years than formerly, largely on account of the fact that the automobile industry has demanded very narrow and many-curved cores for water jackets, etc. Some small cores are made without stiffening wires. But all cores of large or even of very moderate dimensions must have stiffening irons, rods, nails, or grids rammed within the sand. Without these aids the cores would bend, become distorted, or fracture, either when drying or during insertion in the mould, or under the pressure of the liquid metal. Core sands, though dried, are still fragile, and must be carefully handled, but only by proper stiffening can they be enabled to resist the forces of disintegration to which they are subjected. Two examples of grids with rods are shown in Figs. 4 and 5. The cores are indicated in dotted outline. The rods shown in Fig. 4 standing up round the margin of the grid support the deep sand from falling away. Two rods with eyes are cast in to lift the core by. In moulding these grids, the rods and eyes are thrust down into the sand below the grid mould, and stand up to an equal distance above the top face, standing up to a distance equal to the grid thickness, and the metal running round fixes them. In Fig. 5 the grid occupies a central position in the core, the walls of which are sustained with rods that stand out equal distances from the grid, the ends of the rods being bent to assist in the retention of the sand. The core is inserted in the mould as it stands in the drawing.

The grid-like character of the base is not essential when the base is of small dimensions. In narrow cores it is impracticable. But it is always most desirable for large cores, and also when the grid is located centrally, both in order to lighten the weight, to retain and bind the sand, to favour the free passage of the vents, and often to facilitate the breaking up for removal. But when the grid occupies the bottom of a core, and is of very moderate dimensions, a solid plate will serve as well as a grid.

Fig. 6 is a grid that carries a ring of sand which is lifted out bodily from the mould after a loose-pattern flange has been delivered above it. The rods shown

in the figure support the sand over the flange, and are cast into the grid. Two eyes are cast in to lift the grid and its sand. To make the grid, the moulder may have a rough pattern supplied, or he will scoop out a square ring, using a trowel and cleaner, in a levelled sand bed; or use two straight strips from which to ram the straight portions, leaving only the curved corners to be cut and smoothed. The rods are then laid and pushed down midway of the thickness and

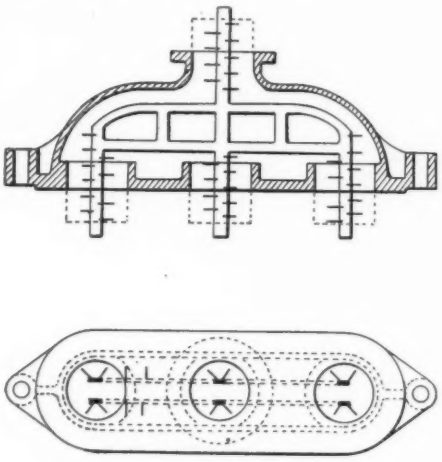

FIG. 9.

covered, leaving the metal to run around and secure the central portions.

In Fig. 7 a pipe grid is shown, for one half of a loam-pattern pipe, or for a half-pipe core. Here, the prongs, like the grid body, are often of cast iron. The semi-circular section is scooped out with trowel and cleaner, and the prongs are formed by pushing a tapered pattern prong diagonally into the mould. Wrought-iron rods also may be used.

The outlines of a large number of grids are such that they cannot be moulded from a standard mesh pattern, like Fig. 1. Sometimes, then, the pattern-maker constructs a rough pattern of the shape required, but more often the moulder cuts the outlines in the strickled open sand bed, as in Figs. 6 and 7. The outlines are marked on the bed by measurements taken

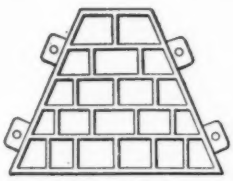

FIG. 11.

from the pattern, the core box, or from the full-sized drawing, in loam work, and the sand is cut out. Or, for a core, the box is laid on the bed, and the grid outlines are marked suitably within the box sides. Some examples illustrating the use of grids will now be given.

A grid is shown in Fig. 8 for one half of the main core for the standard of a vertical engine. This is marked out from the interior of the box, but if required for repetitive orders a pattern would be made, since the form of the mesh precludes the mould being taken from the standard pattern in Fig. 1. As the core is deep, rods are cast in as shown, to support the sand. These are pushed into the mould, deeper on the lower side than on the upper, the latter being next the joint face of the cores. They are of variable lengths below, to follow the spreading outlines of the core from the top to the bottom of the standard.

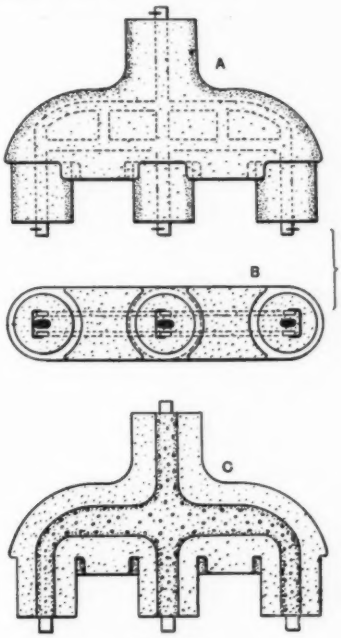

FIG. 10.

Fig. 9 is the casting section of a valve box for a three-throw pump, with the core grid for each half of the core laid within it. The shape can be cut out in the sand with little trouble. The core sand outside

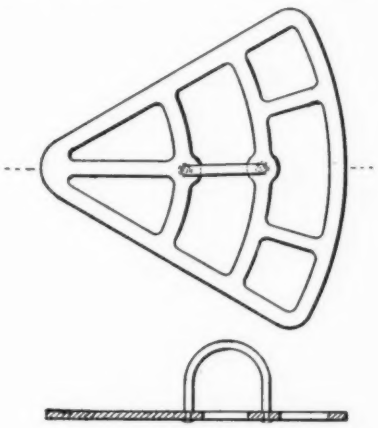

FIG. 12.

the cast grid is sustained on prongs of cast, or wrought iron, made like those in Fig. 7 for the semi-circular sections of the core. This is shown in the face view below. The portions for the circular sections project beyond the print faces, as seen in the upper view, to

accord a hold for the clips which secure the half-cores similarly to those in Fig. 3. The clips are seen in position in Fig. 10. Here A and B show an external view of both half-cores jointed, and C, that of a half-core open in the joint face, showing the gutter or vent channel which collects and discharges the vents from the half-core.

A pattern is made for the grid or cope part, Fig. 11, for carrying the sand over propeller blades. One is required for each blade, and they must be reasonably exact to outline, and slope, with lugs cast on.

The grid in Fig. 12 is generally made from a pattern of iron kept in stock where wheels and pulleys are produced regularly. A large stock of these grids is required for a range of castings of different sizes. In the figure, a riveted sloop is provided for lifting the grid and its core. Sometimes one or more central eyes are cast in as shown in Fig. 4. In that case the stem is stood on end in the mould space, and is supported vertically by means of a rod passed through the eye, and resting on a brick at each end outside the mould.

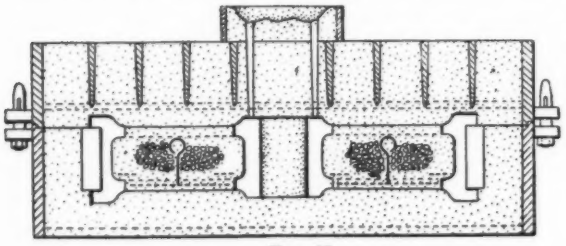

FIG. 13

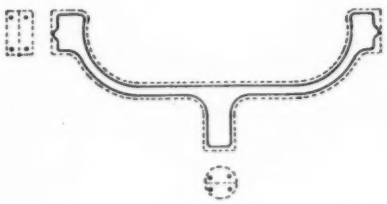

FIG. 14.

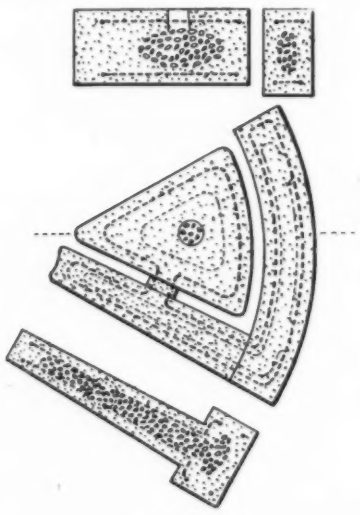

FIG. 15.

Fig. 13 shows such grids, each with a central eye sustaining their cores in a wheel mould. Here, too, loose rods are seen rammed in the cores to extend over the internal ribbings, to support the overhanging sand. When a grid like Fig. 12 is used for bevel-wheel cores, rods are cast in the outer rim of the grid to extend over the slope of the wheel rim to support the large body of sand at that point, for which loose rods would be too risky.

In light cores, and for some intricate forms, core irons are used, made of iron rod, or wire. There is a reason for this besides the suitability of rod or wire to the slender character of the core. It lies in the necessity for the removal of the skeletons of cores from the internal portions of castings. Often they can be taken out bodily, as is the case when an opening as large as the grid exists in the casting; but when the opening is of smaller size they have to be broken up with a hammer and extracted in fragments. When the spaces are too small or too intricate to permit of doing this, rods or wires are used. The balance then has to be struck between the stiffness necessary to sustain the core, and the capacity to straighten-out when pulled by the pincers. Generally, rods and wires range from ⅛ in. to ¼ in.—3-16 in. being a very serviceable size.

In Fig. 14 a core is outlined for the exhaust of a double-engine cylinder, cast solidly, that is *en bloc*, the arching of the core shown being necessary to clear the cylinder bodies. The core is rammed in halves and cemented, requiring two wires of the outline shown. Each wire is continuous, the ends being soldered, or else tied with binding wire. The small loops next the steam-chest faces are for the purpose of securing the cores. When the casting is being fettled, the wires are pulled out with pincers through the exhaust opening, being straightened by the pull.

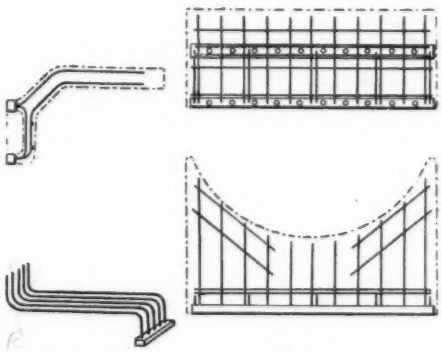

FIG. 16. FIG. 17.

The core in Fig. 15 is for the head of a capstan. One portion of the core takes out the recess for a lever bar, the other for the lightening space adjacent, which lies between the holes for the bars. There is also a segmental portion of core which does not appear in the casting, but is so made for convenience of moulding. A ring print encircles the pattern, because it is moulded on its side, that is, with the vertical axis of the capstan body laid horizontally. These three portions are rammed in one box. All the air is brought away through the central hole in the triangular lightening core, which is connected with the remaining portions through the round hole seen passing through the metal thickness. A cast-iron grid could not be got out of the triangular part of the core, so rods are used instead. They are bent as shown, and soldered, or tied.

Two sets are employed, one each near the outer faces of the core. They are pulled out through the opening that receives the capstan bar.

Rods are cast into a plain piece of bar in a large number of instances. The bar usually enters a print impression, and is the part pulled first out of the casting, drawing the rods with it. Fig. 16 shows a common form, that of the grid for a steam-passage core for a large cylinder. In small cylinders these rods are used alone and separately, instead of being cast into a bar.

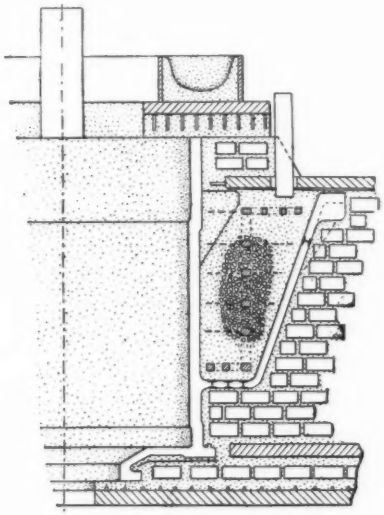

FIG. 18.

A grid having rods cast into two separate straight bars is shown in Fig. 17, being for a large double-ported, low-pressure cylinder, where two steam ports pass into one main steam passage. The two bars are connected firmly with a series of arched rods cast in, and other sets of rods go from thebars into the passage that makes entry into the cylinder. This explains the difference in the length of these rods, as seen in the lower figure, where the curve of the core that abuts against the cylinder core is shown by the dotted line. These rods are tied together near their upper ends with diagonal bars seen in the same view, being bound with fine wire, and with some horizontal rods.

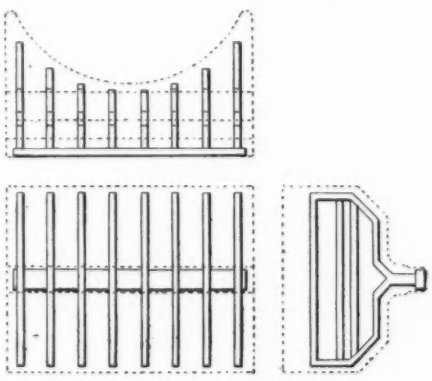

FIG. 21.

A grid with three faces at right angles, with rectangular openings, and having rods cast in the central portion, standing out to various distances from both faces, is shown in Fig. 18, within its core, in position in its mould. It is the lightening core for one of the feet of a low pressure cylinder, cast topside downwards. A grid of this shape has to be rammed in a box from a pattern, unless, which is rather preferable—it is made in three pieces bolted together. This comes out without being broken up.

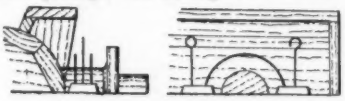

FIG. 19.

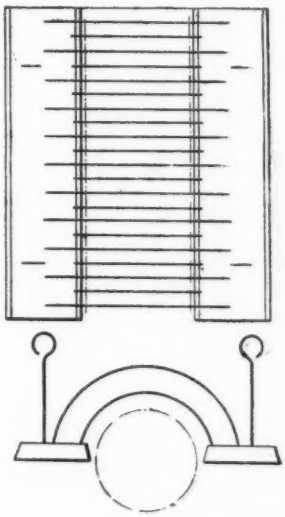

FIG. 20.

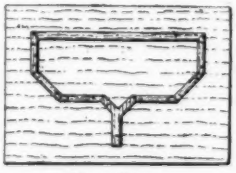

FIG. 22.

Examples of cast-iron bars with wrought-iron rods are shown in Figs. 19 and 20. In Fig. 19 the sand over a branch is carried on the grid shown, because the presence of the overhanging foot would prevent the sand from being lifted otherwise. It is rammed as usual under the foot, and over the branch, upon the grid. The flange, having been left loose from the cylinder, and withdrawn, the grid is lifted by its eyes, along with its sand. The eyes are cast in the grid when supported with a rod on bricks, and the arched rods similarly. Fig. 20 was used for a temporary job —a long drum of large diameter shown dotted, for which a suitable top part with bars was not available. A plain top was used, and the grid was bolted up to its flat bars with the four eyes shown. The arched rods served the purpose of stays to support the sand.

C

How heavy grids are built up with castings is shown by one example, Fig. 21. It is for a large exhaust core too heavy to be stiffened with rods like Fig. 17. The sections are cast from a pattern, Fig. 22, nailed on a board, and stamped into a levelled open sand bed. As each section differs in width from the others, the moulder stops on the different widths with a strip, but the angular portion is alike for all. After these are cast, they are all supported in a mould for the connecting bar, and the bar is cast around them.

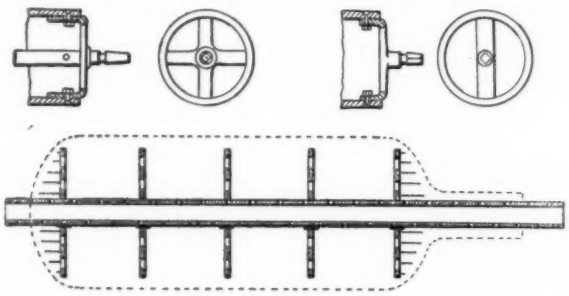

FIG. 23.

There is a large group of grids known as core plates, used on cylindrical sweeping bars to support the hay-bands and loam where diameters are large, Fig. 23. The bar is selected of a size to resist flexure, and the supplementary diameter is made up with plates keyed on at intervals to support the hay bands which they flank. At the outer ends, prods are cast on the faces of the plates, or rods are cast in. The plates have a large number of holes, to facilitate breaking them up for removal, also for lightness, and for the escape of air, and frequently to permit of passing bolts through to prevent the end plates from being bulged and displaced outwards. Iron patterns are stocked for these plates. In a legitimate sense, core bars are grids, since they support the fabric of the core. They are pierced with holes for the escape of gas, and are made both parallel, and tapered, to suit core outlines. The upper group in Fig. 23 shows methods of attaching trunnions to the ends of these bars.

A "NECESSARY" EVIL.—The chief engineer of a prominent manufacturing concern once said that his company considered the drawing office a "necessary evil." Probably his reason was that it was "non-producing." While certainly a non-producer, the drawing office is in many cases a cost reducer, the producer of methods (tools, jigs and fixtures make methods) which lessen the cost of production. The trouble is that in most cases these methods are carried only as far as the machine shop. A designer or draughtsman should understand the foundry as well as the machine shop. He should know how a piece will come out of the sand best, where to and where not to use cores. He should be able to decide after consultation with the foreman of the pattern shop and foundry the best methods to be used in certain cases. The draughtsman often designs a piece of machinery so that it will come within the capacity of certain tools in the machine shop, often making a piece in two pieces where one would do, so that it can then be more easily handled and machined without in any way impairing its efficiency. The pattern shop and not the draughting room is the designer in the case of foundry work. Patterns cost just as much as machine-shop fixtures and should also come under the design of the draughtsman It is not suggested that the draughting room shall, in every-day straight work, say how a piece shall be moulded, but there are many cases where the judgment of the draughting room should show that special patterns, core boxes or fixtures would pay.

Prevention of Piping in Steel Ingots.

A simple method of illustrating the formation of piping in steel ingots is adopted by A. F. Macfarland in a paper recently presented at a meeting of the American Steel Treaters' Society.

According to the writer, the shape and general design of ingot moulds have a great deal to do with the piped steel. Figs. 1 and 2 illustrate two types of moulds in general use. It will be assumed both moulds are filled with molten steel. As the steel cools and freezes it shrinks, the metal nearest the wall of the mould freezing first. The continuance of this freezing and shrinking may be illustrated by the parallel line

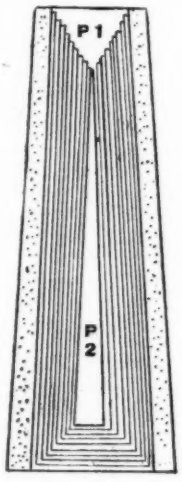

FIG. 1.

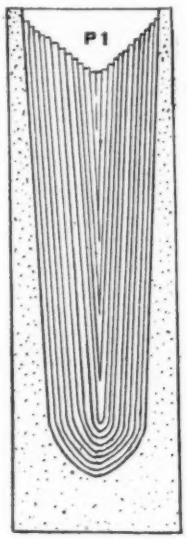

FIG. 2.

shown in the illustrations. In Fig. 1 the primary pipe P_1 will be completely formed, theoretically, and frozen at the bottom of the cavity before the metal in the area P_2 has solidified. This metal in turn will form a cavity on cooling which is known as the secondary pipe. In Fig. 2 the pipe is shown in the upper portion of the ingot, as the steel at the top in this type of mould is the last to freeze.

NOTE.—Our readers will remember that the influence of the ingot type on the piping of steel ingots was first demonstrated in this country by H. Brearley, Iron and Steel Institute, 1906.—ED. F. T. J.

Structure of Steel Runners.

In a Paper read before a recent meeting of the American Institute of Mining and Metallurgical Engineers, Francis B. Foley, metallurgist of the U.S. Bureau of Mines Experiment Station, Pittsburg, dealt with the different crystallisation that occurs in steel runners. In examining steel under the microscope one is constantly confronted with structures which are difficult to interpret. Recently, in a collection of samples for exhibition purposes, the writer found a piece of open-hearth runner metal 2 inches in diameter which had been fractured for use as a sample of cast-steel structure. On polishing and etching a section of this runner for the purpose of photographing a field to typify the microstructure of steel in the "as cast" condition, a variety of structures was found so arranged as to arouse interest at once. For a distance of about 0.065 inch in from the skin of the runner, normal ingot structure was found; this was followed by a zone, about 0.215 inch wide of considerably lower carbon content in which occurred a most pronounced widmanstattian structure; from this point on to the centre of the runner the metal was again of normal ingot structure.

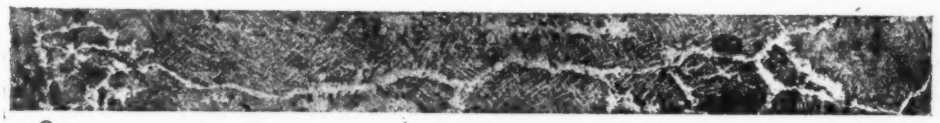

FIG. 1.—SECTION OF CAST STEEL RUNNER SHOWING DIFFERENTIAL CRYSTALIZING, MAGNIFICATION ABOUT 30 DIAMETERS.

FIG. 2.—SECTION OF CAST STEEL RUNNER UNDER MAGNIFICATION OF ABOUT 4 DIAMETERS.

Representative samples were taken from the metal in the three zones for analysis, and the following results were obtained:—

	C.	Ni.	Cr.
Metal from skin	0 34	1.2	0.63
Widmanstattian zone ...	0-21	1.18	0 62
Metal from centre	0.34	1 32	0.67

Such a condition might result from decarburisation followed by recarbonisation of the skin. This section came from one of the branch runners to the bottom of the mould, not from the main runner, and it is difficult to conceive of recarburisation occurring in this portion of a runner. If the metal were stripped while quite hot it is true that some oxidation would take place, but the recarbonisation is unaccounted for. It could not occur by segregation after solidification—the tendency then is for diffusion and homogeneity. The following seems to fit the conditions and is offered as an explanation

The outside layer of normal structure 0.065-inch thick is a layer of metal which was chilled on the walls of the runner brick when the molten metal first entered the runner. As the molten metal flows by, the outside of the stream is cooled by the walls of the runner and crystallisation starts, the crystals so formed being attached to the chilled metal on the wall of the runner. These crystals, being the first to form, are necessarily of the lowest carbon concentration. When the wall of the runner has reached a certain temperature, the outside of the flowing stream of metal comes to a fairly constant temperature, and, that temperature being just under the liquidus, solid metal of low carbon content is constantly separating out of the liquid crystallising on the walls of the runner. The crystals so formed build outward into the stream as it flows. When the difference in temperature between the solid metal attached to the walls of the runner and the molten stream has become so small that no chilling effect is any longer exerted. The formation of these low carbon crystals ceases or perhaps they grow until such a length that they are no longer strong enough to withstand the force of the flowing metal. After the mould has been filled and the metal comes to a state of rest, solidification proceeds normally and the structure of the interior of the runner is the result. In subsequent cooling in the solid state, some diffusion takes place, but evidently it does not become complete. This diffusion is first materially retarded when the metal of lower carbon content passes through its Ar3 point and is stopped completely at Ar1.

Two Solutions Suggested.

The very marked Widmanstattion structure in the low carbon band might have been produced in either of two ways, or by a combination of the two. One possibility is that it is due to the fact that the metal where this type of structure is so pronounced existed in the solid state at a higher temperature and for a longer time than the metal elsewhere. Its freezing point is higher than that of either the skin or the centre metal, and it did not cool as rapidly as the skin but somewhat faster than the centre. The other possibility which suggests itself is that this type of structure formed more readily in the particular part of the runner than elsewhere because of the difference in the processes of crystallisation, and that the ferrite needles are actually in the same position which the original low carbon crystals occupied during their formation and growth.

Pure Gum Shellac.

Its Origin and Chemical Composition.

In the "Metallurgical and Chemical Engineering" of December 10, 1917, a very comprehensive treatment of the origin, manufacture and composition of this singular product appears by C. H. Jones. The following abstract will be interesting to our readers, particularly pattern makers, and for full information respecting the details of manufacture, the entomology of the lac-producing insect and specifications for shellac varnishes we refer to the original article.

The continued and increasing use of shellac in the arts and industries and recent requirements for a pure neutral varnish to resist the action of various chemicals and electric pressures, have awakened an interest in the circumstances surrounding the origin and method of production of the gum, with especial reference to the possible impurities which may enter into the processes employed in obtaining the commercial grades. Investigation has shown that a surprisingly large percentage of the better-informed persons, and even chemists, who are familiar with this everyday substance as an ordinary varnish, have little or no knowledge of its origin, and no information for use in distinguishing its value as compared with other varnishes. There is also little information available on the percentages, kinds and effects of impurities entering into the analysis of the different types or marks.

Origin of Sticklac.

The lac resin from which shellac is derived is made by an insect known as the *æchardia lacca*, and its product, found as an incrustation on the smaller twigs of several types of tree, is broken off with the supporting twig, giving the sticklac of commerce.

The insects swarm twice each year, much as the bee, with about 5 per cent. of the swarm consisting of males. Being gregariously inclined, they alight in densely packed masses on the twigs of the tree.

As soon as the larva alights it buries its beak through the bark into the tender part of the tree, and inserting a sucking tube, proceeds to withdraw the sap. After absorption of some of the constituents of the sap and modification of others within the body, it excretes a fluid at the anal end. This excretion forms a covering over the insect and, slowly hardening on contact with the air, a cell is produced. As these cells are very close together, the whole coalesces and takes the form of a crust.

When about two and one-half months old the female is impregnated by the male and continues to grow and exude lac for another two and one-half months. The ovary becomes so enlarged as to occupy nearly the whole body and is filled with a bright red fluid. This is the basis of the lac-dye. From this fluid the eggs form during the sixth month, at the end of which swarming occurs and the crop is ready for the gathering.

Crops of Sticklac.

India is the source of all shellac for the world markets, and the bulk of the sticklac is harvested there. Some of the latter, however, comes from the Malay Peninsula and Siam to Calcutta factories.

There are four crops gathered each year. The "Bysackie" crop is gathered in April in the Sind, Punjab, Bundelkand, Bengal and Birbhum, reaching the factories in May and June. This is the principal crop of the year, supplying the T.N. (truly native) grade.

Grades of Shellac.

There are two general classifications or grades of shellac: (1) Orange shellac and (2) garnetlac. Button lac is a sub-division of orange shellac. The qualities of orange shellac are determined principally by colour and to a less degree by freedom from dirt, insoluble matter and rosin. Garnetlac comes only in the form of flakes, but in many qualities.

Chemical Analyses.

Shellac consists of lac resin itself, which is the gum shellac; a certain amount of so-called lac wax, a hard whitish or brownish substance more like carnauba wax than any other; a small percentage of moisture and the insoluble matter, which is, speaking generally, either organic matter, the remains of the lac insects, and so-called residue of vegetable, mineral or other substances. Average analyses of high-grade native hand-made goods run about as follows :—

	Per cent.
Lac resin	93 to 94
Lac wax	3 to 4½
Moisture	1½ to 2
Insoluble matter, of which the organic matter is usually two-thirds ...	1 to 2

Low-grade native hand-made shellacs analyse about as follows :—

	Per cent.
Lac resin	91 to 93
Lac wax	3½ to 4½
Moisture	1½ to 2½
Insoluble matter, of which the organic matter is usually two-thirds... ...	2½ to 4 or even 5

The average analyses of machine-made shellacs vary only slightly and run about as follows :—

ORANGE SHELLAC.

	Per cent.
Lac resin	95 to 96
Lac wax	3 to 4
Moisture	1½ to 1.6
Insoluble matter...	0.2 to 0.3

GARNETLAC.

	Per cent.
Lac resin	97.7
Lac wax	0.5
Moisture	1½ to 1.6
Insoluble matter	0.2 to 0.3

It is of course understood that the shellacs above mentioned are free from rosin. If rosin is added, cut down the percentage of lac resin in exact percentage to the amount of rosin.

The analyses of a large number of samples of crude lacs by Dr. D. Hooper for the Indian Forest Service have been averaged into the following table :—

Name of Tree.	Water.	Resins.	Coloring matter.	Resi. due.	Ash.
Kusum (Schleichera trijuga)	1.8	85.6	2.5	9.1	1.0
Ficus	1.8	83.9	2.6	10.2	1.5
Ber (Sizyphus jujuba) ...	2.0	82.7	2.4	11.5	1.3
Palas (Butea frondosa) ...	2.4	77.4	4.3	14.1	1.8

Chemical Composition of Shellac.

Analysis of commercial D.C. shellac made by H. Endemann shows on treating with a caustic alkali solution a residual wax having a carbon content of 82.18 per cent. and hydrogen 14.25 per cent. A complete analysis of the above gave the following :—

4.5 per cent. myricyl alcohol.

8.0 per cent. non-condensable acids (not oxyacid) and impurities.

27.0 per cent. soluble and crystallisable oxyacid.

60.5 per cent. oily oxyacid, only slightly soluble.

Detailed specifications and methods utilised for ensuring the quality of this material are given in the original article.

PALMERS SHIPBUILDING & IRON COMPANY, LIMITED, of Jarrow, state, contrary to rumours that have gained currency, that their shares have not been sold to any firm, and they have not amalgamated with any firm.

Modern Recalescence Apparatus.

By EDGAR R. TAYLOR.*

Whereas the old-time engineer relied to a great extent on secret recipes for the hardening of steel, the modern scientific man has the benefit of apparatus of the highest precision, and to-day we have instruments that will tell us exactly what heat treatment a particular steel requires. Some types of apparatus work on principles which are strictly automatic, whilst other sorts are governed by the time and temperature principle. It is agreed that for delicate research work the latter method is the more suitable. Use is made of the potentiometer for measuring the E.M.F. from the thermo-couple, and a chronograph for recording time intervals.

For works use, there are methods which are really good and even ingenious for determining the recalescence points of steels. For general applicability an apparatus which can be used for determining the recalescence points, both of a sample of steel and a non-ferrous metal will be the most valuable. Such an apparatus, which works on the potentiometer principle, will be described below. A similar apparatus was used in the reseaches of Carpenter and Keeling in 1902-4 in the construction of the iron-carbon diagram. Firstly, a furnace is required to heat up the specimen uniformly. It is obvious that any deviation from uniformity in this respect will mask any small recalescence point in the specimen. One of the most successful furnaces in use was evolved at the National Physical Laboratory and described by Dr. Rosenhain before the Institute of Metals in 1916. The furnace consists of a fireclay tube 2 ft. 6 in. long and 3 in. dia. The tube is used in the vertical position, and is wound for a distance of 1 ft. from the top with ni-chrome wire .0624 in. x 0.04 in., which allows the passage of an electric current, and so heats up the top portion of the tube. The tube is wrapped round with asbestos lagging and filled in between an outer sheet-iron casing with sand or asbestos fibre. The furnace is therefore hot at the top, gradually decreasing in temperature down the tube, until at the bottom the temperature can be made atmospheric by a water circulation. This can be proved by gradually drawing up the tube a sample of copper, which, having no recalescence points, should show a definite rise in temperature, say, every five seconds.

The apparatus used in conjunction with the furnace consists of (1) a potentiometer, (2) a chronograph for recording time intervals, (3) winding gear for raising or lowering the specimen up or down the furnace, (4) a galvanometer with lamp and scale.

The principle of the method is as follows:—

As the specimen is being gradually drawn up the furnace it will be heated uniformly until the recalescence point is reached. Then, owing to the absorption of heat in the specimen, the latter will remain stationary in temperature until the critcal point is passed. If, therefore, on starting to elevate the specimen in the furnace we attach a thermo couple to it, and record the time taken for the specimen to rise every 2 deg. or 5 deg., it is apparent that the time intervals will be uniform—almost precisely—until the critical point is reached. Then a considerable time will elapse before the specimen again commences to rise in temperature. Hence the critical point is accurately fixed.

The details of manipulating the apparatus are as follows:—

The potentiometer is adjusted by checking against a weston normal cadmium cell which is 1.0183 volts at 20 Cent., and opposing the current from a 2-volt accumulator. The galvanometer is connected by wires with the potentiometer, and by watching the spot of light reflected by the galvanometer mirror on to the scale placed two metres away, adjustment can easily be made. If the spot of light reflected on to the scale is not at zero, correction is made by slightly altering the rheostat attached to the potentiometer. The thermo-couple, made of platinum and platinum-iridium, is wedged in the specimen with pieces of mica. The specimen is approximately 1 in. long and ½ in. diameter, and has a hole of ¼ in. diameter bored half-way down its length. A small overhead motor is arranged to draw the specimen up the furnace at the rate of about 18 in. per hour. The ends of the thermo-couple pass into a thermos flask at known temperature, and connection is then made by copper wires to the potentiometer viâ a switchboard. The E.M.F. generated by the couple due to the difference in temperature between the hot and cold junction is thus acting directly on the potentiometer and the galvanometer. Using the knobs of the potentiometer to add resistance to the circuit, the E.M.F. generated by the couple is opposed, so that only a small amount goes to the galvanometer. Hence, if the temperature of the specimen is required at the commencement of the operation, we read off the amount of resistance added in terms of milli volts, adding the small amount represented by the spot of light on the scale (100 cm. = 2 milli volts). The certificate supplied with the couple shows what temperature certain milli volts correspond to, and so any temperature can easily be measured.

Having ascertained the temperature of the specimen in the furnace at the outset, the motor is started, and gradually raises the specimen into the hotter regions. In order to locate the recalescence points, arrangement is made to time each successive increase of 2 deg. or 5 deg. centigrade, according to the accuracy required. The timing is done with the help of a chronograph made by the Cambridge Scientific Instrument Company, Limited. It consists of a paper tape passing beneath three ink pens. Two of the pens are connected by wires to an electrical clock, and register two and twelve seconds respectively, while the third pen is actuated by the operator by means of a Morse key. This key is depressed every 2 or 5 deg. rise in temperature as the operator watches the spot of light on the scale coming from the galvanometer. The reverse operations are performed on taking the cooling curve. The whole operation of taking the heating and cooling curve of a specimen is performed in forty minutes to one hour, according to the class of steel or other metal. The tape is then examined and the recorded times taken for each increase of 2 or 5 deg. noted. The recalescence curve is then drawn, having for ordinates the temperatures and time intervals as abscissæ.

The Wild-Barfield Automatic Hardening Furnace.[1]—It is claimed for this furnace that it can be controlled by unskilled hands. There are two types, viz., the metal furnace pots which permit the current being switched on and off when desired, such pots being used for screw gauges and other articles of precision where oxidation is objected to, and secondly the radiation furnace used chiefly for articles which have to be ground or cleaned after hardening. The Wild-Barfield furnace utilises the principle that at the point of recalescence carbon steel loses its magnetic properties. The furnace is provided with a heating coil which magnetises the object, and with a pyroscopic magnetic detector which indicates the change point. The electric furnace comprises an inner pot of refractory material containing a salt mixture and an outer cylinder from which it is insulated. The inner pot is wound with a heating and magnetising coil, the ends of which are connected to terminals for the electric supply on the exterior of the outer cylinder. The latter is wound with a coil of wire (the pyroscopic detecting coil) similarly connected with terminals to

* Read before the Staffordshire Metallurgical Old Boys' Association, January 28, 1920.

[1] Briefly described in our issue of November last.

the galvanometer circuit. The furnace temperature is brought up to about 800-850 deg. cent. by means of the regulating resistance, a temperature which is considerably above the recalescent point of normal steel. The steel does not reach the furnace temperature, which is checked by an independent pyrometer. The article to be hardened is suspended from an iron wire and placed in the furnace, and immediately becomes magnetised by the current of the heating coil. When the steel reaches the temperature of recalescence it becomes non-magnetic, and is then at the best point for quenching. The loss of magnetism causes the galvanometer to indicate this condition, so the article is at once removed from the furnace and quenched. In the radiation type of furnace an upright cylinder in which the work is suspended is used, the heat being entirely conveyed to the work by uniform radiation from the cylinder wall. A detector shows the exact moment the recalescent point is reached.

The Brearley Curve Tracer.—This instrument, made by the Cambridge and Paul Instrument Company, Limited, is intended to enable the recalescence points of steel to be determined in about 20 minutes. The method consists in placing a uniformly rotating drum with its axis parallel to the galvanometer scale and providing means to keep a pointer coincident with the moving spot of light. A pen is attached to the underside of this pointer and is in continuous contact with the chart on the drum. When the curve tracer is used to obtain heating and cooling curves the galvanometer is connected to a thermo-couple placed in contact with the substance under treatment. The instrument is semi-automatic in action. Assuming that a recalescence curve of a sample of steel is desired, a small hole is drilled in the specimen and into this is inserted the hot junction of the thermo couple. The specimen is then placed in a suitable furnace and a preliminary heating is made to ascertain the approximate position of the recalescence point on the long scale. The curve tracer is moved to such a position on the platform that the recalescence point shall be within range of the chart drum, and the proper test is then carried out by gradually heating of the steel specimen, during which the deflections of the spot of light on the scale are noted. When the moving spot of light comes within the range of the tracer drum, a handle is turned so as to keep the pointer coincident with the spot. At the same time a clock drive is released so that the drum begins to rotate with the result that the pen traces out on the chart a time-temperature curve.

Discussion.

MR. LAMB (President) remarked that the apparatus described was not set up in half an hour; it was very delicate and intricate, particularly the first piece of apparatus. It was not easy to get a perfect temperature throughout the furnace. He had used a larger tube than that described by the lecturer, viz., 3 ft. long and 1 ft. 6 in. wide and wired round on all sides, and had found a remarkably large range of temperatures, varying up to 100 degs.

MR. WILKINSON considered that from the description given of the Wild-Barfield furnace it did not appear to be used for determining and recording the recalescence points of steel, but doubtless it was a most useful piece of apparatus to have in use for the hardening of small tools. Regarding the remarks of Mr. Lamb, his experience of varying temperatures was largely due to the fact that the tube of the furnace he used was very much wider than that described by the lecturer.

MR. WALDRON agreed with the President that one could not ask a chemist for a curve in a few minutes, and the length of time taken to set up the apparatus and take the curve was certainly a drawback to the use of such delicate apparatus in actual works practice. It was possible to get the information required by the more simple method adopted in actual practice. Some articles would not harden unless a temperature of 20 or 30 degs. above the recalescence point was obtained.

MR. BECKLEY described the first method as the latest and best for delicate work. The Wild-Barfield furnace was not intended for taking the critical ranges: its use was for hardening small tools, but it had its faults. He found that the steel when nearing the point when it was no longer magnetic, and the spot of light was nearly off the scale, a "bump" occurred in the light; he (the speaker) then took out the article and dipped same before the whole of it had approached the non-magnetic state. The third process described was the most widely used.

Die-Casting Plant.

At the recent British Industries Fair, held at Castle Bromwich, Birmingham, February 23 to March 5, the Monometer Manufacturing Company, Limited, included a comprehensive exhibit of their various types of melting furnaces, including automatically heat-controlled pressure die casting machines, white-metal melting furnaces, aluminium, iron pot melting furnaces, lip axis and central axis crucible tilting furnaces for the melting of brass, gunmetal copper, steel, etc., and printers' type re-melting and stereotyping furnaces.

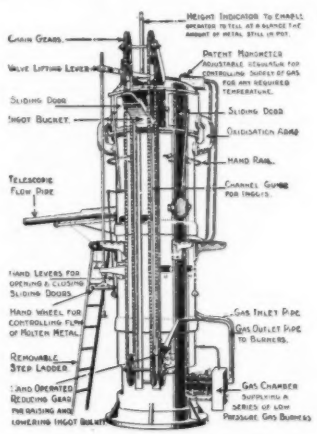
Height Indicator To Enable Operator To Tell At A Glance The Amount Of Metal Still In Pot.
Casing Gears.
Patent Monometer Adjustable Regulator For Controlling Supply Of Gas For Any Required Temperature.
Valve Lifting Lever.
Sliding Door
Ingot Bucket.
Sliding Door
Oxidisation Arms
Hand Rail.
Telescopic Flow Pipe
Channel Guides For Ingots.
Hand Levers For Opening & Closing Sliding Doors.
Hand Wheel For Controlling Flow Of Molten Metal.
Gas Inlet Pipe
Gas Outlet Pipe To Burners.
Removable Step Ladder
Hand Operated Reducing Gear For Raising And Lowering Ingot Bucket.
Gas Chamber Supplying A Series Of Low Pressure Gas Burners.

FIG. 1.—MONOMETER DIE-CASTING MACHINE.

The monometer automatic self-acting heat regulator is suitable for controlling temperatures of industrial furnaces requiring heat control within 5 deg. F., and has a range of temperature from 100 deg. F. to over 2,000 deg. F., and is made in various sizes. It can also be adapted for the controlling of various steam apparatus.

ELECTRICAL DETECTION OF SUBTERRANEAN OIL.—It is stated that crude petroleum has been located electrically in the shallow oilfield near Corsicana (Texas), and that further tests are being made around Burkburnett. A series of batteries is used for the test, the negative terminal being connected to a wire which is dropped into a dry waterhole, valley, or indentation, and the positive terminal being connected to a "land wire," which is used to make contact at various points on the surface of the field investigated. It is stated that the higher electrical resistance of oil, compared with other constituents of the earth, permits it to be located by the reduced deflection of a sensitive instrument in the circuit.

A Suggested Lay-Out for a Small Foundry.

By HARTLAND SEYMOUR.

In many factories too little attention is paid to the details of lay-out in the foundry. Initially, when the works are planned, great care is taken to put the foundry in the best place with relation to the other departments in the factory. This is very necessary in order that transportation between the foundry and

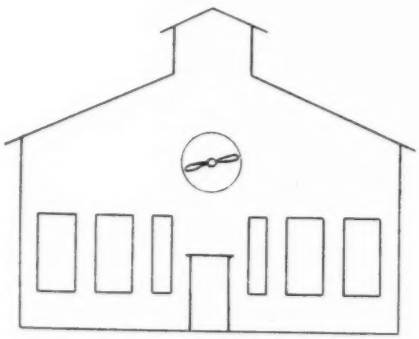

FIG. 2.—END ELEVATION.

the pattern and machine shops should be quick and easy.

On the other hand, once the foundry is in the best position relative to the remainder of the works, it is often left at that and the internal arrangements of the foundry itself are frequently neglected.

For the purposes of this article, perhaps, it intended to describe a small foundry now in operation in a small engineering works. This particular foundry is shown in the rough lay-out. Here the foundry is a separate building and is connected with the pattern and machine shops by the tram-lines which run down the centre of the foundry. The transport of materials to and from the foundry is rendered extremely easy.

The foundry building itself is 100 feet long by 50 feet wide. It is constructed of brick with steel frames. It will be noticed that the window space is exceedingly large. This is to be recommended, as foundries are too frequently very ill-lighted. This particular foundry is exceedingly light, and this factor has a great deal to do with the small percentage of accidents sustained. The windows are of the swinging type and afford good ventilation. The roof is also well ventilated. Besides this, as shown in the rough sketch, an ingenious ventilation device in the shape of a discarded aeroplane propellor was erected above the door at each end of the shop; these propellers are driven by motors and aid the ventilation very materially.

A system of overhead runways is provided from the cupolas and running down the building. The cranes are very easily operated by hand. In addition, small trolleys run from the core oven to the core-room, with a small turntable provided at the junction of these lines. The cleaning room is also served by the runway system. The junctions of the runway system are operated by hand, so that one of these cranes can be easily diverted from one line to the other.

As far as the remainder of the lay-out is concerned, the diagram is self-explanatory.

The whole shop is exceedingly compact, and the operation is thereby greatly facilitated. It should be mentioned that the office is raised above the floor level and commands a view of the whole shop.

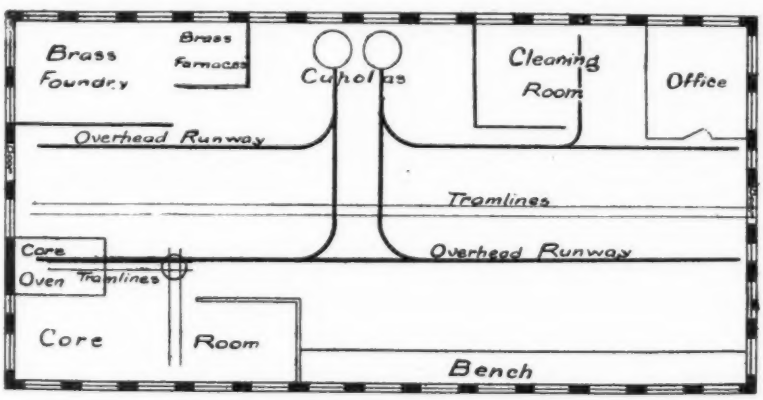

FIG. 1.—GENERAL PLAN FOR SMALL FOUNDRY.

Correspondence.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—We have had some trouble with one of our cupolas used for iron melting, owing to the firebrick lining giving way after the first "blow," and we think that it is possible that it may be caused by the air blast. There is no air-belt on the cupola, but just two air inlets, coupled from a Roots blower. We already have a pressure gauge on the air pipe, between the blower and the cupola, but, of course, this does not show the volume of air which enters the cupola.

We believe there are meters on the market which measure the volume of blast entering the cupola, and we think you might know of some firms who make or supply these meters. If you do, will you kindly pass the information on to us?

Yours, &c.,
M. T. C.

February 3, 1920.

CHANGE OF ADDRESS. — We are informed that the Department of Scientific and Industrial Research has been removed to 16-18, Old Queen Street, Westminster, S.W.1.

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NOTES AND COMMENTS.

The Experimental Moulder.

The complexity of the circumstances governing the production of waster castings in the iron foundry is not quite so thoroughly appreciated as it might be. In the past it has been generally the rule to attribute or at least attempt to attribute wasters to the constitution and character of the metal. As a result, and as an endeavour to check waster castings, the employment of trained chemists or metallurgists was resorted to, who by exercising control over the raw materials is enabled to practically ensure uniformity in the constitution and character of the molten metal. So far, so good. It is, however, beginning to be more thoroughly appreciated that waster castings are due to numerous other circumstances, some of which are beyond the control of the foundry chemist. Mr. H. Traphazen, of the Toledo Steel Casting Company, grouped these causes into the following classes:—(1) The carelessness of the workman; (2) Over-production tending to careless sloppy work; (3) Melting defects; and (4) sand defects. In addition, he strongly emphasised the truism that "Hot lively metals will ensure a maximum of good castings." This is especially true of "green sand" moulding.

Mr. Traphazen's most interesting suggestion was that "an experimental moulder, whose sole duty is to investigate the proper method of gating and heading castings as they come into the shop, should be employed by every up-to-date foundry."

This suggestion is one of considerable value although it is certain that many of the departmental foremen and even the foundry managers actually fulfil this position in all but name. Every foreman and foundry manager, we feel sure, pays full attention to his scrap pile and endeavours to formulate some reason for any particular defect, and in turn to put into effect the necessary remedial measures. In the smaller foundries the present organisation is probably sufficiently effective from this point of view; but in the larger foundries the managerial staff is in many cases sufficiently burdened with other matters connected with organisation that it is unable to devote sufficient attention to this aspect of the subject as to enable it to comprehensively investigate the various defects due to the different causes.

In such cases the employment of an individual whose sole duty is to investigate the causes and remedies of waster castings has much to recommend it. By putting the whole of this into the hands of an individual and making his sole duty the solution and remedy for the various waster castings would go far in securing the desired object.

One of the great defects of this proposal, apart from that of securing the right type of man, is that of allocating the power to put into operation the necessary remedial measures suggested by the examination of the defects. This depends so much on the principles and practices in vogue in any particular case, and also on the characters of the individuals concerned, that it is almost impossible to lay down any rule of general application. Whilst the difficulty is a great one, we feel sure that it is not insurmountable.

After all, when the known origin of the greater part of the defects is considered, it would appear on the basis of prevention being better than cure, that some system of inspection of moulds previous to closing and casting would be a valuable means of remedying the troubles of waster castings.

In the engineering shops the adoption of more or less comprehensive systems of viewing the various parts at the different stages of their production has undoubtedly resulted in a considerable reduction in the defectives produced and the elimination of them at an early stage of the manufacture.

It would appear to us that some such scheme as this

is equally applicable in the foundry, and we feel that an inspection of the moulds by a competent man previous to closing, whereby defective workmanship and defective materials may be detected, would be by far the better step to take in improving the organisation with a view to eliminating wasters. The mould inspector or mould viewer, as he might be termed, in addition to being a competent moulder of considerable experience, would be also required to possess considerable tact and ability and a knowledge of the requirements of castings as indicated by the drawings. Finally, whether an experimental moulder or moulding viewer is created in any foundry, his success depends entirely upon the type and character of the man selected.

De-Oxidising Molten Iron.

A new ferro-alloy for de-oxidising molten cast-iron was discussed at the annual meeting of the American Foundrymen's Association in October last in a paper by Dr. Richard Moldenke, entitled "Cerium in Cast Iron."

This is a new addition to the already extensive list of so-called deoxidisers, which include ferro-titanium, ferro-vanadium, etc. This metal cerium would appear to possess at least one advantage over the others in that it melts at 1180 deg. C., and its ferro-alloy lends itself readily to assimilation by the molten cast-iron.

The cerium group of metals is exceedingly active chemically. They have a very great affinity for oxygen, and the heats of formation of the oxides run in the range of those of aluminium and magnesium. The result is the liberation of great quantities of heat besides the scavenging action on the metal into which the cerium alloy is introduced. This, besides purifying the metal before pouring, prolongs the fluidity of the metal appreciably. It may therefore be expected that castings will be softer and more dense, as feeding through the gates and risers is prolonged and the formation of combined carbon is retarded correspondingly.

The tests mentioned below were made with grey and chilling irons, with varying proportions of the cerium alloy, in order to note the improvement in the strength of the castings as a consequence of the additions in question. Unquestionably the deoxidising action was excellent, but whether any beneficial results other than greater machinability and soundness can be obtained will remain for further investigation.

In making additions to a ladle full of molten iron experience shows that about 0.1 per cent. of the element to be experimented with should be sufficient to effect deoxidation, and usually none of the element can be traced in the casting unless at least that amount is used. If the percentage is increased the excess of the element in question above the quantity necessary for deoxidation will alloy with the iron itself and may or may not give additional beneficial properties to the metal. Hence in the tests made, the additions amounted to 0.05, 0.10 and 0.15 per cent. cerium, lanthanum, etc. These figures are based upon an alloy containing 70 per cent. of the rare metals in question.

It is of extreme interest to note these attempts at deoxidation in view of the allegations of one section of metallurgists that the presence of oxygen is decidedly beneficial. This was dealt with in these columns of our last issue.

We certainly feel that before definite statements are made as to the deoxidising effect of any metal or alloy, the amount and influence of any oxygen present should be fully established. Improved physical properties of any metal or alloy on the addition of even small quantities of a rare metal does not necessarily mean that the rare metal addition has a deoxidising influence. J. E. E.

The Institution of Automobile Engineers.

The seventh meeting of the Session of the Institution of Automobile Engineers was held on Wednesday, February 4, when Mr. A. P. Young and Mr. H. Warren read an interesting paper entitled, "The Process of Ignition," embodying the results of a vast amount of experienced work in connection with magnetos..

The following note was received from a member in Canada, and should be of interest to the industry :—"I wonder if the British makers realise what a demand there is here for the better quality British motor car of about 300 cubic inches capacity (six cylinders), in spite of the overwhelming majority (about 99.9 per cent.) here of cars made by United States firms.

"*Three cars and six trucks* is the record of British automobiles imported into Canada during eight months of 1919, and not all of the cars were new."

First-Aid and Ambulance at Factories and Workshops.

A memorandum on this subject has been issued by the Home Office for the guidance of occupiers of factories and workshops in establishing at their works a satisfactory first-aid and ambulance service. A well-equipped and well-organised system of first-aid and ambulance is invaluable in the interests both of the employer and the worker, and its provision is one of the most important parts of welfare work. The benefits of an effective service may be summarised as follows :—

Suffering is alleviated.

The workman who has met with a slight accident is enabled to return to work almost immediately in comfort and with a sense of security.

Minor accidents are prevented from developing into serious injuries as a result of septic infection or blood poisoning. Experience shows that it is not always a severe accident that in the end proves the most serious. The loss of a limb or even of life has ensued from an apparently trivial, but neglected, injury.

The recovery of the workman and his return to work after a severe accident may be materially expedited.

A full and useful description of the types of first-aid boxes, dressing apparatus and equipment of ambulance-rooms is given, and several model designs of ambulance and first-aid buildings are illustrated.

Value of Proper Records.—It is important that proper records should be kept of all cases treated. This is, of course, of most importance in regard to the cases treated in the ambulance-room, but employers, in view of possible serious developments of even slight accidents will find it advantageous to arrange for every accident, however slight, which is treated at a first-aid box or in the ambulance-room to be recorded.

In an Appendix the essential details of the Orders of the Secretary of State requiring provision of first-aid and ambulance arrangements in factories are given.

Book Received.

We have received from the publishers, Messrs. Emmott & Company, Limited, "Mechanical World" Office, 65, King Street, Manchester, their Year Book for 1920, price 2s. net.

UTILISATION OF SLATE WASTE.—A new use for the vast quantities of waste material produced in quarrying slate has, according to the "Chemical Trade Journal," been developed in Carnarvonshire, where a company is powdering the waste and selling it as a filling material. It is said to be useful in the manufacture of asphalt, bricks, cement, abrasive soaps, cleansers, glass, linoleum, moulded and mechanical rubber goods, pottery, slabs and tiles, distempers, paints, insulators, etc. It produces bricks which are at the same time dense, strong, and hard, and which show a considerable saving in manufacturing costs. The silica content ensures that they are capable of withstanding a very high temperature.

XUM

The Electrical Process of Steel Manufacture.*

By J. A. Holden.

Although there has been a number of widely different types of electric furnaces designed and patented for the manufacture of steel, very few have survived, and as the arc type is the one almost invariably adopted in this country, the author proposes to deal entirely with the manufacture of steel in the "arc" furnace.

At the outset, it should be stated that the production of sound steel from an electric furnace is entirely a metallurgical proposition, and that in a well-designed arc furnace there are no electrical problems. Further, the metallurgical considerations are not all peculiar to the "electric" process. For instance, melting in a basic open hearth is comparable in many ways to the melting stage in the basic electric furnace; the problems of castings temperature, the method of casting and the velocity of casting, are problems common to all processes of steel production.

The electric furnace, however, has one very strong characteristic, and that is the case with which a reducing atmosphere can be maintained, and, further, the strong tendency for an oxidising slag to give up its metallic oxides by the action of the arcs on the slag surface. This tendency becomes very pronounced when charges are very rapidly melted, although from many points of view rapid melting is very economical. It increases the life of the furnace lining, the output is high and the melting losses are low. When working acid-lined furnaces the advantages of rapid melting become very apparent, particularly when the charge contains such valuable metals as tungsten and molybdenum.

With a basic-lined furnace operating upon impure materials it is not always expedient to melt with great rapidity, for in common with all steel-melting processes the more quickly the charge is melted the less the oxidation. It is generally understood that the removal of carbon from a bath of steel is due to dissolved oxides, and if it is desired to effect a rapid reduction of the carbon content, it means that it is necessary to feed iron ore or mill scale whilst the bath is at a low temperature, and before the charge is completely melted. In operating a small furnace provided with a heavy current, this question of oxidation becomes an item of considerable importance, particularly if the charge contains more than 0.5 per cent. of carbon, together with an appreciable percentage of phosphorus; for a small bath of metal taking a comparatively heavy load, say 2 tons, with 600 kilowatts, is quickly raised to a very high temperature. The result is that its solvent capacity for ferrous oxide is reduced, which in turn determines the speed of oxidation of the carbon and phosphorus.

A rod of steel or iron placed in a bath of steel as soon as the charge is thoroughly melted and hot enough to pour well will indicate the amount of dissolved gases. If the content is high the rod will produce a very vigorous evolution; but as soon as the carbon in the bath falls below 0.15 per cent. this evolution will no longer take place.

By very erratic feeding of iron ore or mill scale the bath becomes overcharged with oxides, and this will give great difficulty during the deoxidising stage. It will increase the duration of the heat; and, further, it will necessitate the use of large amounts of ferro-silicon. When melting ordinary mild steel scrap containing about 0.3 per cent. of carbon, with not more than 0.08 per cent. of sulphur and phosphorus, there is no difficulty in refining the charge, so that by the time the scrap is liquid the carbon will have fallen to 0.1 per cent., and the phosphorus will be no more than 0.015 per cent.

When dealing with more phosphoric charges it is not quite so simple, particularly with such material as common wrought iron, which may contain 0.25 per cent. of phosphorus and only 0.1 to 0.2 per cent. of carbon. To facilitate the melting of charges of this description, it is advisable to place in the bottom of the furnace pig-iron to increase the carbon content of the charge to 0.3 to 0.4 per cent., and then to melt with the highest available voltage. On a 3-phase Héroult furnace a voltage of 110 is ideal for this class of work. During the melting stage it is then only necessary to feed a few lumps of hematite ore, and so promote the oxidation of the phosphorus simultaneously with the oxidation of the carbon.

An ideal melting slag should contain an excess of ferrous oxide—between 30 and 40 per cent. It should not have a large percentage of silica, otherwise it will not hold phosphoric acid; for practical working 9 per cent. is the maximum.

Although arsenic very rarely figures in specifications for steel, it may be interesting to point out that this element is easily removed from steel melted in an electric arc furnace under a slag containing an excess of ferrous oxide. With a charge containing about 0.08 per cent. of arsenic melted under the indicated conditions the final steel would contain not more than 0.015 per cent.—a figure which is comparable with the finest Swedish steels.

Deoxidisation and Desulphurisation.

It is generally known that the finishing slag in the electrical process of steel manufacture contains at least 60 per cent. of lime. Further, it should be free from oxides and be perfectly white in appearance when cold. Many theories have been advanced to account for the desulphurising reaction. For example, it has been stated that the reaction proceeds between calcium carbide which is supposed to be present in the slag, and ferrous sulphide in the steel. Support is given to this theory, because experience teaches us that when the slag is loaded with carbide of calcium the final steel invariably contains only minute traces of sulphur. On the other hand, it should be pointed out that it is possible to desulphurise a charge and yet have present only infinitesimal amounts of carbide. The author is inclined to the view that some of the desulphurising is brought about by the reaction of ferro-silicon. This reaction can only be explained by assuming that silicon sulphide is first formed. Several statements written by Dr. Hatfield* indi-

* Read before the London Branch of the Institution of British Foundrymen, Jan. 8, 1920, Mr. F. E. Pitts in the chair.

* "Cast Iron in the Light of Recent Research," pages 214, 215.

cate that silicon sulphide may exist in iron-carbon alloys (cast iron). So far, however, conclusive proof is lacking.

Whatever chemical reaction is responsible for the desulphurising, the practical conditions which are necessary are thoroughly understood, and it is found that in making ordinary carbon tool steels this stage of the manufacture gives very little trouble. When, however, very mild steels are being manufactured, which contain only about 0.1 per cent. of carbon, it sometimes happens that desulphurisation takes place only to a very limited degree. This is particularly pronounced when the final product contains only a small proportion of silicon. By raising the silicon content to about 0.2 per cent., it is possible to desulphurise with a greater degree of certainty; but even then the reaction is never so complete as when manufacturing high-carbon steels.

To illustrate the difficulty of desulphurising very mild steels, the author gives some particulars of a cast of very mild steel—a micro. of which is shown in Fig. 1. The material had the following composition:—Carbon 0.08 per cent., manganese 0.04 per cent., silicon 0.03 per cent., phosphorus 0.01 per cent., sulphur 0.039 per cent. It will be observed that this metal almost approaches pure iron in that

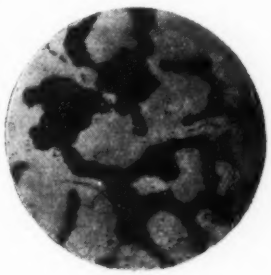

Fig. 1.

Fig. 2.

it contains 99.8 per cent. of iron, but the sulphur content is distinctly high for an electric-furnace product. Although the finishing slag was in perfect condition, it shows that the removal of sulphur in very mild steel is not a simple operation.

Why the re-action proceeds so readily in the presence of carbide of iron is difficult to explain. It might be suggested that the small amount of manganese in the above mild steel explains the reason for the high sulphur content, but it must be added that a steel containing 0.6 per cent. of carbon and only 0.04 per cent. of manganese would be easily desulphurised.

Special Steels.

In these days of automobiles, aeroplanes, and high-speed machine tools, the demand for alloy steels which will withstand severe duty has increased enormously. In bygone days it was customary to make such material in the crucible; nowadays, however, the electrical furnace is almost invariably used. Taking the case of high-speed steel, the electrical-furnace product has assumed considerable proportions. Acid-lined furnaces are often used for the manufacture of this steel, and they are worked almost exactly as a crucible. Others are worked with a basic lining: the whole of the charge is put in (as in crucible practice), and the steel is made throughout under a deoxdidising slag.

It is, however, not uncommon to make this steel in quite a different manner. Selected steel scrap is melted in a basic furnace, decarburised and deoxidised in the usual manner, and then a thick, white desulphurising slag is obtained. In other words, a bath of almost pure iron is obtained, and then the necessary alloys are added to meet the required specification. To obtain the desired tungsten content there can be no doubt that ferro-tungsten is a very suitable alloy. It can be obtained in pieces sufficiently large to enter the bath without floating upon the slag; in consequence, the loss of tungsten is negligible. Further, as the alloy contains about 15 per cent. of iron it melts comparatively easily. The addition of the other alloys calls for no comment, except that under the right conditions there is loss of neither chromium nor vanadium.

Sometimes it is required to melt scrap containing chromium in which it is desired to retain as much as possible of this element. We therefore have the somewhat anomalous position of wanting to oxidise prosphorus, and simultaneously retain an element which is very prone to oxidise. The only thing to do is to compromise, making as little oxidation as is necessary; using such scrap as armour-plate shearings, which contain about 0.03 per cent. of phosphorus, it is not by any means difficult to retain the greater part of the chromium and still reduce the phosphorus to about 0.02 per cent.—a figure which will meet almost any specification.

The author has found that the removal of chromium is a difficult and time-consuming operation. The reason for this is easily explained. The arcs themselves tend to produce a reducing atmosphere, due to the presence of minute particles of carbon which, in fact, constitute the arcs. In addition, that part of the electrode which extends into the furnace is of necessity the same temperature as the furnace, and is in consequence consuming oxygen all the time. Any electric furnace melter who has endeavoured to decarburise high-carbon steel will appreciate this difficulty of retaining very oxidising conditions.

Of the many alloy steels which are made by this process not the least important are the silicon steels. The silicon in the form of the ferro alloy is added as soon as the metal is dead melted, and of the required carbon content. With a thick, white slag, and using only medium-sized lumps of the alloy, it is not difficult to obtain the silicon percentage within a very narrow margin of the desired

figure, and also obtain 100 per cent. efficiency from the added alloys.

Nickel steels can be made in the electric-arc furnace, both for case-hardening and for oil-hardening. The former variety are usually very low in carbon, and sometimes a small percentage of

TABLE I.—*3 per Cent. Nickel Steel (Héroult).*

Capacity of Furnace, 3 tons. 600 K.V.A.

Charge.	Slags.		Additions.
	1st.	2nd.	
Turnings,	Lime	¾ cwt.	1½ cwt.	Ferro Si. 35 lbs.
70 cwt.	Iron ore	¼ „	—	„ „ 10 „
(Ni. steel)	Fluorspar	—	35 lbs.	„ „ 10 „
				„ „ 5 „
				„ Mn. 33 „

Analyses.

	C.	Si.	Mn.	S.	P.	Ni.
Bath sample ..	—	—	0.08	—	—	2.95%
Pit samples ..	0.12	0.15	0.45	—	—	2.90%

Current Data.

Units used 2,250
Duration of heat .. .. 4 hours 5 minutes.

shrinkage will necessitate such enormous feeding heads that the process is not economically possible.

Steel which has been refined in a basic electric furnace is exceptionally pure, and in consequence has a comparatively high freezing point. It therefore requires skilful teeming to pour a large number of boxes without having either a skull in the ladle or stopper rod trouble. A very important item in this connection is the finishing condition of the slag. It has been found that if a thick

TABLE II.—*Steel Castings (Héroult).*

	Per cent.	Per cent.	Per cent
Carbon	0.40	0.40	0.33
Silicon	0.45*	0.22	0.23
Sulphur	0.015	0.022	0.019
Phosphorus	0.010	0.012	0.011
Manganese	0.700	0.49	0.59
Yield point (tons per sq. inch) ..	25.36	25.56	18.58
Max. stress „ „ ..	39.00	39.5	35.14
Elongation (per cent.)	27.50	27.5	20.00
Red. of area „	36.40	36.3	23.00

* Silicon content gave the steel an excessive shrinkage; castings required large feeder heads. This composition is unsuitable for ordinary steel castings.

cream-coloured slag is maintained up to the moment of casting, it will eventually solidify on the top of the ladle, and so insulate the liquid

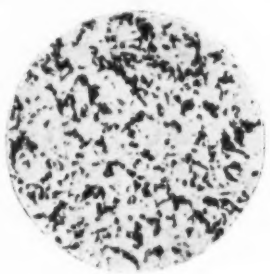

FIG. 3.

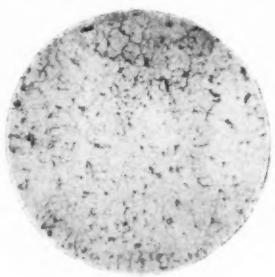

FIG. 4.

chromium is added. When steel scrap containing nickel is available the electric-furnace nickel steel can compete with either the open-hearth or Bessemer material, and sometimes no addition of metallic nickel is required. This explains why the new process is in such a favourable position for meeting the competition of the older and better-known processes.

Table I. illustrates this point very clearly. It will be seen that the cast in question—a case-hardening nickel steel—was made entirely from nickel steel turnings, and no addition of cube or shot nickel was required.

Electrical Steel Castings.

The term "steel casting" has been applied to a variety of iron-carbon alloys. They vary in machining qualities, and particularly in soundness, or rather unsoundness. In fact, the production of a steel casting which, when machined, exhibits no blow-holes or slag pockets used to be an exception. With the electrical process sound steel castings can be made without using any patent fluxes and without adding considerable percentages of deoxidisers. It should always be remembered, however, that as electric steel has a high shrinkage, it is not desirable to have more than 0.2 per cent. or 0.25 per cent. of silicon. Otherwise the high

metal underneath Protected in this manner, it is not necessary to cast at an excessive temperature, even when handling very light work. With an old furnace, particularly with poor refractory materials, it is more difficult to prevent the finishing slag from becoming very mobile. By the addition of one or two shovelfuls of dolomite the formation of magnesium silicate increases the viscosity considerably, usually sufficient to counteract the effect of a high percentage of silica.

In Table II. is shown the mechanical tests which have been obtained from castings made from Héroult steel.

To conclude this paragraph, the author gives a few micrographs showing the structure of electrically-melted steel castings. Fig. 1 illustrates the coarse structure of an imperfectly annealed casting, and Fig. 2 illustrates the same steel annealed for maximum tenacity; it was heated to 900 deg. C., and maintained at that temperature for six hours, and then cooled in a current of air. The carbon in this steel was 0.22 per cent. The next micrograph (Fig. 3) shows the structure usually obtained from a steel which is allowed to cool in the furnace after being completely annealed, while Fig. 4 indicates a specimen which has been heated to 900 deg. and cooled in the furnace. It will be noted that these steels are free from inclusions.

Methods of Casting.

The production of steel ingots which will work up into bars and billets free from defects is by no mean an easy undertaking. The process of manufacture may have some bearing on the quality of the steel, but defects such as pipe and cracks are common to all processes. The reliable qualities of well-made crucible steel cannot be disputed, and when one examines the process of manufacture it becomes apparent that the keynote of the whole production can be summarised with the word "care"—care in the selection of the materials, care in melting, and care in casting. If we compare this with the procedure in, say, open-hearth or Bessemer shops, one cannot wonder that large slabs crack in the mill or fail under test. Whilst with electric steel is not possible to imitate the methods of casting adopted by the crucible melter, it is possible to use the same skill and judgment.

Turning to the crucible process for a moment, we see that the puller-out takes his pot of liquid steel and passes it to the teemer. The teemer, whose eye is no doubt superior to any optical pyrometer, decides whether the steel requires pouring slowly

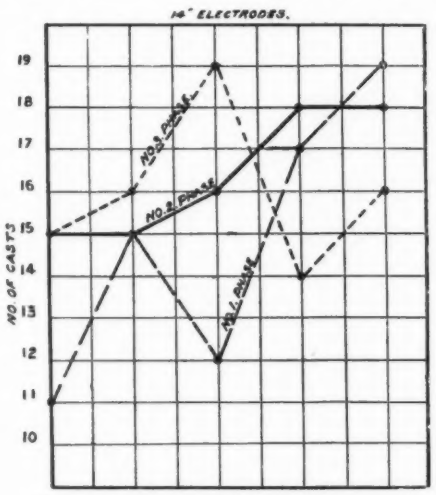

FIG. 5.—ELECTRODE CONSUMPTION ON 3-TON HEROULT FURNACE, 600 K.V.A.

or quickly, and he accordingly regulates the speed of teeming by judgment, which has only been gained by long years of experience. In making electric steel, however, where we are handling tons instead of pounds, we have to resort to the use of a ladle, which in turn involves the use of stop rods and nozzle.

Now, as the available temperature in the electric furnace is extremely high, it is, perhaps, not surprising that the early steels made by this process did not reach the anticipated standard of excellence—particularly where the operations were controlled by a furnaceman who was paid a tonnage on the amount of steel cast. Such men would not be particularly keen about the condition of the ingots provided they got every ounce of steel into the mould, and so received their tonnage dues. Perhaps the simplest way to cast a steel ingot is the method known as "top running" direct from the ladle simply into a mould standing on an iron plate. Where defects, such as "pipe" and surface are of no importance, this method might pass muster; but when it is desired to produce steel of the first quality at an economical figure much more elaborate methods are necessary.

Moulds which are filled with the wide end uppermost and feed through a hot nozzle, or feeder head, yield the least amount of scrap through piping. In order to test this point, the author some years ago cast two 12-in. ingots from steel of similar composition. The first was dish-cast with the narrow end uppermost. After breaking, it was found that the secondary pipe terminated 2 ft. from the ingot top—equivalent to 44 per cent. of the length of the ingot. The second was dish cast into a mould with the wide end uppermost. After the ingot had been sawn at a distance of 4 in. from the tip it was found that the pipe terminated 7 in. from the top of the ingot.

As bottom-run ingots are usually cast in groups, each mould is necessarily filled very slowly; and it

TABLE III.—*Log of a 75 per Cent. Carbon Steel (Héroult).*

Capacity of Furnace, 3 tons. 600 K.V.A.

Charge.		Slags.		Recarburisation and deoxidation.	
	Cwt.	1st. cwt.	2nd. cwt.		lbs.
Turnings ..	65	Lime	1½	1½	Anthracite .. 85
Heavy scrap	10	Iron ore	1¼	—	Ferro Si. .. 25
		Fluorspar, 35 lbs.			(50%) 5
					5

Final additions.		Current data.	Casting data.
	lbs.		
Spiegel ..	170	Units used, 2,376	Six 10½ cwt. ingots dish cast.
Pig-iron ..	40	Duration of heat, 4 hrs. 50 min.	One 6 cwt. ingot, top run.
Ferro-si. ..	6		Two cwt. slop.

Analysis.

	C.	Si.	Mn.	S.	P.
Required ..	0.75%	0.20%	0.45%	—	—
Produced ..	0.76%	0.21%	0.42%	0.018%	0.007%

Forging Data.

Seven ingots yielded 86 per cent. of their weight in bars *i.e.*, 14 per cent. includes cropping and scale.

is well known that such ingots are much less liable to crack than simlar steels top-run direct from the ladle. Further, ingots of the former class usually have a very clean surface, which is smooth except for ripple marks.

Mr. Kilby* states that bottom-cast ingots are prone to contain fluxed runner bricks: in other words, they suffer from inclusions. No doubt there is a certain amount of truth in this statement; but if the presence of minute quantities of inclusions are of no moment, bottom running is a very satisfactory way of dealing with alloy steels, such as nickel-chromium and chrome-vanadium.

The effect of dish teeming is to fill the moulds very slowly, because the dish reduces the size and

* "Steel Ingot Defects," J. M. Kilby, Iron and Steel Inst., 1916 and 1917.

the velocity of the stream of liquid steel. In passing through the dish the steel cools considerably, so much so that even an inexperienced eye can see the difference. But dish teeming gives a splashed surface, and as appearances have some commercial value, this operates against dish teeming. The writer has found that the effect of the splashes is almost negligible, and by way of an example he gives an illustration of a cast of electric carbon tool steel made from a Héroult furnace, which was dish-cast (Table III.). On referring to the log of this heat it will be seen that the ingots yielded 86 per cent. of their weight in bars of the first quality.

With alloy steels containing high silicon percentage, as, for example, chisel or cold sett steel with 1½ per cent. of silicon, it is necessary to use a large feeder head, because the excessive shrinkage would otherwise yield very pronounced piping. With these, as with chromium steels, the tendency of the metal to fold becomes an objectionable feature. Here the advantage of the mould the wide end uppermost becomes obvious. Further, to promote a free-running steel it is certainly wise to cast the metal hot into the ladle, and then run the ingot very slowly by means of the comparatively small nozzle in a dish.

Electrodes.

Electrodes are used which are made from either amorphous carbon or from graphitised carbon. Claims for advantage can be advanced for both of these types, but so far graphitised electrodes have been installed almost invariably in furnaces of large capacity, say from 12 tons upwards. This is, perhaps, not very surprising when we consider the very large current used on such furnaces. Graphite electrodes have one striking advantage—they can be joined without resorting to a joining paste or solution. Further, as they have such high electrical conductivity, only small diameters are necessary. This means that it is possible to adopt a light construction for the electrode holders, together with a corresponding light design for the framework of the hoisting gear. In addition, as graphite can be easily machined, it is possible to avoid a large collection of stub ends. It should be noted, however, that, as graphite has a large electrical conductivity, it has also a correspondingly large conductivity for heat, and this means that the waste in use, which is usually called "pointing," often amounts to a serious consideration. Of late years, however, economisers have been invented which do much to get over this objection.

Although graphite has many advantages, quite a number of points can be advanced in favour of amorphous carbon. The low electrical conductivity of amorphous carbon in practice proves a decided advantage. By reason of their large diameter they act as very powerful insulators to the furnace roof, the life of which is much longer than when graphite electrodes are used. In the experience of the writer the economy in this direction amounts to 33 per cent. of the roof costs. In contradistinction to graphite electrodes, a paste is necessary for joining. As carbon electrodes are very difficult to machine, the threads—both in the electrode and on the screw—are made by moulding in a die, and by such process of formation they are, of necessity, not so accurate as cut threads. A joining paste is therefore used to secure intimate contact and prevent arcing inside the joint. An excellent material for forming this paste is the finest quality Ceylon plumbago ground extremely fine, and mixed to the consistency of treacle with hot anhydrous tar. As the life of the electrode is to a large extent determined by the character of the joint, careful attention is amply rewarded by the results attained. A preliminary trial is made with several screw plugs, and one which grips the thread is chosen. A paste which is previously heated to about 90 deg. Centigrade is smeared over the lower half of the screw. This is then twisted into position. Before the new electrode is attached, the projecting half of the screw is also smeared lightly with the hot paste. In order to prevent slipping in the holder the electrodes are made slightly tapered, and to secure correct joining the diameter is measured beforehand with a caliper gauge of suitable dimensions.

In conclusion the author gives some results obtained from English-made amorphous carbon electrodes (Fig. 5.).

Discussion.

Mr. Bartlett said the Author spoke of casting ingots in one case with the small end up and in another with the large end up, and he spoke of the "pipe," which they termed the "draw" in the cast-iron business. In casting with the large end up he understood that the temperature was reduced quicker on the top end, and the draw in the bigger volume of metal did not extend so far to the other end.

The Author explained that one got the same amount of pipe if two steels were cast at the same temperature in two moulds of similar size, irrespective of the shape of the moulds. When casting with the thin end up one got the pipe in an elongated pencil formation which went right into the ingot.

Mr. Willis said that when he saw the tremendous heat evolved from the carbons on to that steel he wondered whether that form of electric furnace could be used for melting the non-ferrous metals. In regard to the melting of non-ferrous metals, how could one, when melting brass, keep in the copper and the zinc, too? He thought the zinc would volatilise, before the metal was fluid, by the tremendous heat from the electric arc. Had the Author any experience of melting non-ferrous metals with the electric furnace, or could it be modified to suit that work?

The Author said the Newcastle Alloy Company were experimenting on the melting of scrap brass, but the loss of zinc was terrific, even when melting brass 33 per cent. zinc and 66 per cent. copper. It was possible to get almost pure copper. It was almost a commercial proposition to make pure yellow copper from brass scrap in the arc furnace. He thought for a proposition like that the Bailey type of furnace was better, where one got a lower temperature. In melting galvanised sheerings in the arc furnace the zinc was all driven off in five minutes, going up in enormous clouds. He did not think it could be prevented.

Mr. Benbow remarked that at Brinsdown all the ladles poured from the bottom. In iron work they poured from the top of the ladle. He would like an explanation of that.

The Author said when iron was taken from the cupola it was possible to cast it and keep the slag away from the metal, but the steel from the electric furnace had a lot of slag on it. The slag

was very fluid, and if a mould or box were filled direct from the top of the ladle by shanking there would be a lot of slag mixed with the steel.

Mr. Benbow said in pouring from the ladle the Author said the slag went down into the steel. If one had plug runners, and got the steel into the bay, why should the slag go into the steel? It should float on the top.

The Author said the steel had a high freezing point. It froze very quickly. Iron remained fluid a long time. In melting iron in the electric furnace it was possible to pour as one did from a cupola. That was done in the case of synthetic cast iron. It was done at a much lower temperature than was possible with steel.

Mr. Read asked why the electric steel was freer from blow holes than steel from an ordinary furnace?

The Author explained that after the second slag the furnace was free from oxygen, and the arcs were all the time acting upon the oxides in the metal. Eventually the steel was dead melted. To promote the reaction, ferro-silicon was added from time to time, and samples poured until one appeared which was absolutely dead. In other processes the steel was killed with ferro-manganese in the ladle, but sometimes the latter was thrown into the furnace. In the Bessemer converter, if the metal was not cast very soon after the manganese was dead it froze. In a well-designed electric furnace one could get an almost invariable temperature of 3,000 or 4,000 deg. C., and the metal could be kept fluid until it was free from oxides, or dead melted.

Major Gordon asked whether electrically melted castings were a commercial proposition nowadays, when we had got peace?

The Author said it depended upon local conditions. Perhaps the two determining factors were the price and the amount of good scrap that could be obtained locally, and the price of current. Working an electric furnace in London and buying steel scrap from Aberdeen was not a commercial proposition. In Sheffield they were paying about 1d. a unit for current. At that figure it became doubtful whether the electric furnace could compete with the Siemens or the Bessemer converter for making ordinary castings, but for making special castings such as trolly wheels, or first-rate castings, even at 1d. electricity could compete with any process. Where current could be obtained at about 0.3d., as it could in one or two places in England, the electric furnace could compete with any process, provided scrap could be obtained reasonably and locally.

Mr. Elliott said in pre-war days his firm, who used a considerable number of engine castings, from ¼ cwt. to 3 cwt. each, got castings from all over England and Scotland, but could not get satisfaction. At last they tried the great Essen firm, and they never saw a bad casting. He would like to know why they made their castings so perfect in comparison with our shops?

The Author said he had come across one or two men who had worked at Krupp's, and learnt that they used electric furnaces for the manufacture of steel castings years before they were used in this country, and it was possible the castings Mr. Elliott mentioned were made from electric steel. The steel castings exported from Sweden and Norway were also of excellent quality, and these were made from electric steel. If a high price were paid for the castings Mr. Elliott mentioned it was possible they were crucible melted.

Mr. Elliott said the cost was 10 to 15 per cent. higher than the castings obtained in this country, but that did not matter.

The Author said there was also a firm in Belgium which had a very good name for castings. About the same period they were using electric furnace steel.

Mr. Elliott remarked that the outside appearance of the Krupp's castings was also better. They never put paint on to cover up the bad parts.

Mr. Slater said he had had a little experience in crucible steel and Bessemer converter steel. Did the Author think the electrically melted steel would be of as good quality as the Bessemer converter steel? He remembered some months ago when a toothed wheel 8 ft. in diameter and 6 in. in depth was being cast, it was found that by casting electrically melted steel the wheels were liable to crack. With the same conditions and the same temperature the converter steel stood up to the test, and they never had one crack out of the twenty-four they made. In the wheels made of the electric steel there was a series of small holes round the bottom of the castings, but not the top. He supposed the Author cast the billets he had mentioned in the ordinary way in an iron mould. Did he cast them by a dish, and did he think that by casting them slowly one would get a better casting than by casting them as fast as possible from an open hearth. Would he cast them from the bottom and with a dish? The castings for his wheels were very mild steel.

The Author thought that it was not perhaps a question of electric steel not being suitable so much as not having the composition of the steel right. In making steel from the Bessemer converter a high manganese was always used to keep it sound. If the same composition were made in the electric furnace one would be almost sure to have trouble. When buying electric steel castings the specification should be almost similar to that for crucible steel. Electric steel approached crucible steel very nearly in quality, and was much superior to either open hearth or Siemens steel. If the ingot mould were filled very rapidly with steel it cracked very badly. It was necessary to dish teem or run a group of ingots at once from a common runner. Unfortunately dish casting gave a splashed ingot, but the body of the ingot was better and worked up all right, and the splashes came off when the steel was put in the forge fire.

Mr. Elliott, referring again to the holes in the bottom of the castings, said it was often suggested that the moulds were not dry. They put a mould in the stove, brought it out and tarred it, and made sure it was dry, but found the same result.

The Author said he had noticed if ingots were tarred they got pin holes just under the skin. He thought it best to cast electric steel in sand moulds which had not been treated with tar.

Mr. Slater said even with the converter it was customary to tar the moulds. On one occasion he remembered this was omitted, and the skin was far better. He found painting with a little plumbago and china clay mixed was better than the tar.

Mr. Thomas asked whether a casting like a hammer block could be made as cheaply, in proportion, with electric furnace steel as more intricate castings?

THE AUTHOR said electric steel was too good for hammer blocks. Ordinary common steel was good enough. Electric steel was only used for the best castings.

In reply to a further question from Mr. Thomas, the AUTHOR said electric steel was as suitable as any for making an intricate design. Provided it was cast in the right mould, it was probably superior to any other steel. If it were subjected to severe stresses or tests the test results would be very regular from electric steel. The same results could be got time after time.

MR. WILLIS said he had been struck with the Author's remarks about the high grade steel he made. He (Mr. Willis) could not make good non-ferrous metal out of scrap, but the steel men accentuated the fact that they could use scrap for making the best grade of steel. He had seen recently at a steel foundry a pile of stuff that looked very rusty and much oxidised, and he wondered what it was composed of. There were perhaps 50 or 60 tons of it, and he wondered whether it was possible to get high grade steel from what appeared to be rough and inferior scrap. It would be interesting to know how the oxide was eliminated so thoroughly, and how the steel was produced. He did not see how the composition of the resulting steel could be known so well as that produced by the Bessemer converter, in which more standardised iron was used, and carbon or other constituents of a certain percentage were added to get the desired result.

THE AUTHOR said brass or bronze was melted in a crucible in an atmosphere of burning coke. There was a vast amount of sulphur round the copper, and no doubt the copper picked up sulphur. Most metals melted in a coke fire furnace picked up sulphur, and also certain impurities from the crucible. Copper corroded crucibles very much and caused reactions. Steel was melted on a hearth of dolomite, and the only gases present were the rarefied gases of the atmosphere. On the top of the steel there was a large blanket of slag, which was free from oxides, and was all the time acted upon by a reducing arc, so much so that the arc formed carbide of calcium, which immediately reacted with any gases present. He did not agree that the composition could be got every time with the Bessemer converter. The blower might not turn the flame down at the right moment. To get the composition right in the electric furnace it was necessary to take a sample and analyse it. It was two distinct operations. Scrap was melted to make bar iron. To make a hard steel, carbon was added in the form of charcoal, anthracite or pig-iron; a sample was taken, and ferro-manganese, ferro-chromium, or whatever else was necessary was added. To make electric steel economically a good service of chemists was necessary, so that results of analysis could be got rapidly and accurately. A good chemist would give the required result in about 20 minutes.

In reply to Mr. Ellis, the AUTHOR said steel as well as copper would take up sulphur from coke when made in crucibles. The crucible process could only be made to work with pure iron such as Swedish iron. The scrap used in making steel in the electric furnace was only turnings which might be looked upon as valueless. When steel was made in the crucible process it was made from metal that had been once worked, and in that sense of the word it was only scrap. There were tons of steel made in crucibles from electric furnace scrap. There were steel works not a hundred miles from London who sent all their casting leads to Sheffield, where it was made up with ferro-chrome and made into high-quality steel. That was because they could not get bar iron at anything like the same price. The steelmaker's dodge was to put his low-melting material, such as charcoal and ferro-manganese, in the bottom, and that helped the scrap to melt easily. The wrought iron was the last to melt. To make a ton of steel by the crucible process consumed 35 cwt. to 2 tons of coke, and it required four or five fires for each pot. Charcoal or spiegel or ferro-manganese should be put in the bottom.

MR. BENBOW asked what was the difference in the contraction of electrically melted steel and open-hearth steel?

THE AUTHOR said the contraction of electric steel was decidedly higher than that made by any other process, because the steel was sound. This gave a lot of trouble in making special steels with high silicon content. It was necessary to have very large feeder heads or keep the silicon or manganese percentages very low. That replied somewhat to Mr. Slater's remarks about the wheels cracking when made of electric steel and not when made of converter steel.

THE CHAIRMAN asked what were the commercial advantages claimed for electric steel melting, compared with the other methods; what figure electric current would have to be at before electric steel melting became a commercial failure; and what, roughly, was the capital involved in laying down an electric steel-melting plant?

THE AUTHOR said an advantage of the electric furnace was that it was possible to take impure and low-priced material, such as steel scrap, boiler punchings, borings, turnings, etc., and refine it into steel equal to Swedish Bessemer or Swedish Siemens. It was impossible to do that by any other process. With regard to the relation of price of current to the commercial possibilities of the process, that depended on a great number of factors. For a foundry equipped with up-to-date machines and well organised he should say 1d. a unit was about the maximum figure he would recommend. With a 12 or 15 ton furnace, if the labour cost were very low, one might go a little higher. The capital involved in laying out a shop would depend on the size of the furnace. If a couple of 7-ton furnaces were put in a capital of about £100,000 would be required.

MR. ELLIS remarked that a great advantage of the electric furnace was that anything up to the size of the doors could be put in, whereas with the converter one had to get small pieces that could be put in the cupola.

MR. ELLIOTT said he understood that at the present day a steel plant was producing with current at 1.83d., and with Diesel plant and oil, etc., at present prices current could be produced at .532d.

THE AUTHOR said at a large blast furnace combustible gases were used for generating the current, which was obtained for the capital outlay and the cost of maintenance. At Foyers the British Aluminium Company had harnessed the water. If they had to buy current at .25d. or .2d. they could not sell their aluminium. In Canada for the manufacture of ferro-silicon the current had to be generated at 1d.

Institution of British Foundrymen.

EAST MIDLAND BRANCH.

Presidential Address.

By H. H. Moore (Loughborough).

The following is an abstract of Mr. Moore's presidential address before the East Midlands Branch on November 22, 1919:—

Production and the Human Factor in Foundry Management.

The existing industrial crisis has without doubt seriously roused the British foundryman to the all-important question of "efficient productive capacity." The task yet to be performed in that direction is colossal, and will take a long time to carry out, for it has to be perfected by those responsible for production, *i.e.*, the managers of the works and foundries, and the men under them, and ascendancy can only be gained by systematic, hard, slogging work.

Our old methods of production will have to be displaced wherever possible by methods which will allow of obtaining a greater amount of useful work for a given expenditure of energy"; the foundries will have to be better equipped from all points of view, more highly organised, and run by highly-trained staffs.

In order to meet the problem of increased production satisfactorily, we must not be afraid to take advantage of the experience of others, holding fast to the good and avoiding the wasteful, and continuously make such improvements as may be dictated by an ever watchful habit. Standardisation must become much more the order of the day than it has been hitherto, and every article of manufacture must be scrutinised in detail with a view of reducing variety; and re-designing on sound mechanical lines, to suit efficient manufacturing methods, will have to be resorted to.

The war forced on to us the so-called "intensive production," in such a manner as to prove the value of production *en masse*, and of labour-saving machinery when properly worked on systematic lines as a means of securing greater output, with lower production costs and greater earnings to the workmen, and this fact was never previously fully grasped in this country, although it had been established for years in at least one other country. It is an accepted axiom that only the prompt eradication of groovy methods can promise progress, and is it not remarkable that many of the old groovy methods are found to be the most laborious methods, taken all round?

It is clearly in the general interest of the nation that machinery should be substituted for hand labour wherever practicable, just as it is a social duty to ensure that no one is paid a wage below what will support a proper existence; but, as a matter of fact, the latter cannot well be secured without the former, for it is the use of machinery which frees us from the over-laborious toil which the winning of our daily bread otherwise demands.

The profitable operation of good plant has not been so generally understood in this country as in the United States of America, where the manufacturer is favoured by certain unique circumstances, for he has the largest home market in the world, and he can put his wares on the market practically with no regard to customer's fads. This makes it easy for him to follow a policy of turning out goods in large quantities and of standard pattern: two essentials which, after proper, careful and bold preparation, lead to low production costs combined with good-quality work.

Quite a large number of our home manufacturers are now fully alive to these conditions, and have already adopted or are preparing to adopt them, and will surely profit by so doing; but many of our customers in England demand individual details and alterations in pattern which render manufacturing, in the real sense, very difficult and often impossible.

The serious shortage of skilled workmen needs pressing attention, and the question of proper and fair apprenticeship must be dealt with at once, so that the youths of our country may not be allowed to drift into all sorts of occupations with no proper skilled training, and satisfactory inducements must be provided to secure a proper class of youth to enter the foundry trade.

The large body of workers ranking next to the management and supervisors must be allowed proper opportunities to rise in position, as in the U.S.A., where opportunities for advancement are more or less unrestricted, and where many of the most practical and efficient organisers have worked up from the shop and foundry floors. In this respect I would mention the necessity for improvement in the educational facilities now existing in this country as compared with the countries from whence emanate our keenest industrial competitors, and I hail with great hopefulness the advent of the so-called "Fisher Bill," the proposed increase in Secondary Schools, and higher educational institutions generally.

A better atmosphere must be created in the shops and foundries in order to secure the really proper and essential effort being put forth, and this can only be secured by a humane and practical administration. Any means of fostering the right atmosphere in the shops and foundry is worth time and trouble. With the exercise of proper discipline, *ésprit de corps*, loyalty and unswerving obedience are generally cultivated under a just and rigid rule, and it is not that penalty for infraction is swift and certain, but that in return for service there are, or should be, certain compensations which in any analysis cannot be overlooked. Mutual hostility between staff and men is a certain proof that discipline in its true aspect has been neglected. Some of this hostility is a legacy from the past bad industrial conditions which obtained in some parts of this country, and which are happily fast being remedied, and the outlook for the future is by no means black.

Labour is human, it is individual, not necessarily collective, and not so far removed in spirit from those who are apt to regard its manifestations with a kind of patronising scorn. Putting ourselves in the other man's place, or attempting to do so, gives a much more sympathetic understanding, and the necessary discipline is just the co-ordination of effort, not the infliction of undue penalty.

Human energy is a limited quantity over a given period of time; discipline can get considerable effort for short spells, and reasonable effort all the time, hence over-pressure never pays. The value of discipline is great, but, generally speaking, it is wrongly viewed. Disciplinary measures are not necessarily methods of penalty, they may be easily measures of reward. In literal fact, gratitude is more or less a sense of favours to come, and then anticipation is a valuable incentive to effort. It may sound strange, but few men are lazy from

choice. There often exists a reason for slacking; it may be that health is the cause, or monotony of occupation, which in time sterilises effort. The more human the administration, the more likelihood of loyal service; and as the total units of human energy available in any period of time are a limited quantity, it is a paramount duty to avoid their wastage.

Few men wish to exhaust all their daily store of energy for their daily task, and where shop conditions are adverse because of poor equipment and bad hygienic conditions, the working day appears much longer than where more rational conditions obtain. This is the same thing as saying increased production depends in many places upon better conditions. Modern mechanical appliances have advantages both for employer and employee; to the former they represent increased output, to the latter an easier day's work with a greater amount of energy reserved for his own uses. It is simply that the ratio between useful and total effort is altered to give greater efficiency and more beneficial work. Lord Leverhulme says: "Man is not a machine." He is the master of machines, and by inventing better machines, and bringing more machinery under his dominion, for productive purposes, he will be able to create a bigger fund of wealth, out of which he can take a greater reward for his own services.

It has been stated, with some truth, that the foundry trade has not yet fully applied labour-saving devices which use human energy economically, but under the spur of national necessity the foundry industry has accomplished productive marvels, and under the existing national necessity for increased production granted the power to apply mechanism and scientific management in an unstinted measure, the future can be made secure. If labour is to be ensured against want, poverty for increased production, granted the power to allow the more intensive methods whereby the wealth it requires can be created. To this end the constructive minds of industry have to explore the opportunity of improving the productivity of the foundry and shops by exploiting a more satisfactory system of payment by result, from which the existing suspicions and restrictions can be cut out and mutual confidence restored.

One of the most important developments in the United States of America, as affecting costs and output, is what is known as scientific management. It is comparatively new and not generally adopted, but in many cases it has proved a success without doubt. Its methods are really scientific and far-reaching. Its relation to manufacturing has been stated as the same as that of chemistry to the production of dyes. It is so broad in its influence that it deals as compeltely with unskilled labour as with skilled labour or with a supervisor or manager. Its importance lies in the fact that it deals with the greatest number of workers, the machine operator, the untrained worker, either in purely handwork or in headwork, or the combination of the two. The leading principles of the experts in this science are well worth noting:—

(1) Changes in method of manufacturing, to be undertaken slowly, only as rapidly as they can be kept in hand, absorbed and operated by management, staff and workers: (2) increased output: (3) increase in wages; (4) lessened fatigue; (5) selecting the task the individual is best suited to undertake.

The order of work is (first) a complete study of conditions; (second) compiling, tabulating, and digesting facts; (third) suggesting new methods; (fourth) training staff and workers in improved methods.

In the opinion of many leading experts it is only a matter of time when this system must be universally adopted. Successful competition would appear to be difficult without it. The Institute of British Foundrymen, the members of which include both employers and employees, in some respects has characteristics which are common to America generally, that is, in respect of the full interchange of opinions and information even amongst those producing familiar articles, the visiting of each other's works, comparing notes, writing papers giving details of processes and methods, with a freedom that makes for progress. This should lead to changes for the better all round, and freedom from conservatism, and make us to get out of the old English way of being content with old methods and out-of-date plant.

I now take this opportunity of mentioning a matter often overlooked by those in control of our shops and foundries. When introducing new methods of production there is one force which should not be carelessly disturbed. It is sometimes termed the momentum of practice, or inertia of custom, or just plain habit, and the sense in which I refer to it means the condition of body, or mind, or both, as established by a repetition of an act or mental process. Its importance in the industrial world is based on the condition of mind and body by which a man acts with greatest precision, ease, comfort and efficiency. This condition must not be carelessly disturbed, for there is found to be a deep-rooted antipathy to abrupt change.

Nearly all skill, dexterity and facility in performance of work is due to acquired habit, and this fact alone shows the value of habit in an industrial organisation, and more especially so when we realise that habit is a disposition as well as an aptitude to do work. The practice brings an involuntarily tendency to continue, and with it an ease and reliability in performance. There are men who during the early and most impressionable years have been subjected to an environment that has established habits of thought and action of a kind unfavourable to the existence of a more desirable kind. Such men are handicapped in trying to take on other kinds of habits, but since habit may be built up by mere repetition, there is a chance to take over many of these men. After passing the most impressionable stage, man acquires his habits of work almost wholly under force of circumstances, and it is this point which leads one to realise, as far as shop or foundry conditions are concerned, how important it is that favourable conditions should obtain if we are to build up success in the industrial world. Men should be led to work along habit lines, or there is great difficulty in co-ordinating their work with the work of others, but when all are following a fixed routine the all-essential co-ordination becomes possible, and then we obtain an organisation working on habit lines, and since efficiency much depends on strength of habits we are led to selecting methods that tend to the greatest habit-building and strengthening process.

This, like every other road of investigation of the elements that affect industrial success, leads us directly to the choice of policy that favours the most complete sub-division of operations. This sub-division should be carried out as far as ever practicable, so as to give each worker the advan-

tage of the skill and the efficiency of action that is only to be acquired by reasonable repetition. It also leads us to the kind of specialisation which concentrates the largest possible organisation to the smallest possible range of work. I often read, and read again, the writings of a well-known American engineer, and would quote a paragraph from one of his works:—

"We lift up a man when we take a worker whose greatest achievement has been to inefficiently handle a shovel, and by patience we teach him to do better work, by which he creates more value, and by which he can obtain a better wage for himself and family. If his brain is not made to guide a nation, this work may not be so degrading as it may seem. The work for each should be of the highest type available for him. One of the greatest crimes against this or any other mortal is to make him discontented with his natural place in the world."

SHEFFIELD BRANCH.

Foundry Practice.

At a recent meeting of the Sheffield Branch of the Institution Dr. Longmuir addressed the members on "General Foundry Practice." Dr. Hatfield presided.

Dr. Longmuir explained at the outset that he had not had time to prepare a paper, but proposed to talk to them about general foundry practice. He proposed to take a survey of the general foundry field. Far too often, especially in a city like Sheffield, foundry practice was regarded as steel casting. In Bradford, for example, foundry practice was looked upon as grey-iron casting. There was a tendency to forget that general foundry practice covered brass and bronze, grey iron, malleable and cast iron, and steel. The art of casting had been known in Britain for several centuries; and right away from the beginning of founding in this country progress had been made by what might be called trial and error. It took 95 years to get up to a weight of three tons. Trial and error was a costly method of progression.

The early progress of the founding industry with trial and error had gradually introduced a habit, which had strengthened in its passage from father to son, of not wanting to depart from the known path. All early progress was the result of practical experience and experiments, and very often the early founders had to dip deeply into their pockets to pay for their experiments, which made many of them reluctant to experiment.

The speeding up of foundry development began with the introduction of science. Science was first brought into the founders' industry by that very debateable question of examination by analysis. The experience gained by the introduction of science to the industry had been proved to be beneficial, but it had proved beyond all question that science and practice must go hand in hand and work together. The scientific man, if a real scientist, was in his way just as practical a man as the most practical moulder. There should be no science which had not a practical bearing. In foundry work the metallurgist must work with the foundry foreman, because the latter often possessed knowledge which the former did not. Given a combination like that, each working with the other, very great progress could be made. Steel castings could only be made commercially successful by the aid of chemical analysis. Perhaps some of the early chemical work done in the grey iron foundries was done by rather young men, who in their enthusiasm thought that chemical analysis would solve every foundry problem. They were enthusiastic, and overstated their case. They knew now that chemical analysis could not solve every problem.

Metallography offered a very great aid indeed to all founders, whether brass, iron or steel, and in many cases it would offer a solution as to failures and little troubles which analysis would not. Mechanical testing was in one sense perhaps not a scientific aid in that it was simply a precaution adopted by the purchaser in order to ensure getting the article as specified. Given a union between practice and practical science, this country had nothing to fear from any other country in the world. The skill of the British foundrymen was second to none, although he was a little conservative. The skill of the British metallurgist could not be beaten, even by Germany. The union of the metallurgist with the foundrymen would place this country in its proper position as the recognised country for foundry work. Economic conditions would certainly force the union forward.

In the ordinary run of commercial castings, those castings which had to pass the water, hydraulic, steam or air tests gave the most trouble. If only some simple method could be found of testing beforehand whether any given casting would stand a given pressure, then a really scientific aid would be given to the foundrymen. As things were to-day, it meant that castings had to be made over again if they proved to be faulty under the test. A comparatively big casting would involve a big cost, and until it was put to the full load test no one could say with real certainty what the result would be. In that direction, then, there was a big field for development. In regard to freater production, greater use would have to be made of mechanical tests, of handling material and saving physical labour. Then, too, in regard to the purely mechanical side of producing castings, quicker production would have to be achieved and effort made to reduce the work of the moulder. Moulding machines were as yet in their infancy, and if the engineers can get more standardisation in their requirements, a good deal could be saved in costs.

One advantage of the high cost of materials was the necessity which would arise for a closer scrutiny of materials, such as tin and copper. Every ounce of material possible would have to be saved, and in the direction of new alloys there were big fields still to be explored. Again, in the direction of saving scrap and waste there was a big field. Dr. McWilliam and himself years ago advocated the principle of having a man in the foundry to look after the scrap, and see that it was sorted out into separate bins.

Education was a very thorny subject, continued the lecturer. The first thing any foundryman should be trained in was moulding. He should be, above all, a qualified moulder, preferably able to produce a satisfactory casting and be thoroughly master of the fundamentals of the art. Again, he would certainly put mathematics and machine drawing in a learner's curriculum before metallurgy. Mathematics were essential to everyone engaged in the foundry. The ability to read a drawing was essential to every moulder, and particularly to the loom moulder. No loom moulder

should be entirely at the mercy of the pattern-maker.

Discussion.

DR. MCWILLIAM said that if foundry apprentices took the advice to heart with regard to learning mathematics they would never regret it. In bringing science to his aid the founder should not forget physics, for he would find with its aid that life was much easier for him.

CAPTAIN RUNDLE referred to Dr. Longmuir's statement that it would be advisable to get some method by which they would know if a casting would stand water pressure. He thought it was generally recognised that failures they came across in steel castings were mostly not from that cause, but from practical defects in the casting. He agreed that the high prices would tend to scientific progress, because it would be to manufacturers' interests to find out how to do the most with the expensive material at their disposal. With regard to education, he agreed that a knowledge of mathematics and mechanical drawing was most desirable. It had occurred to him that what was wanted in training the young men was some knowledge that could be put before them in an elementary way. Standardisation would enable them to eliminate a great deal of the present variety of work which led to uncertain results.

DR. HATFIELD, in closing the discussion, said that he took applied science to be the conscious application of natural laws to everyday life, and all of them who fully observed all the discoveries, ancient and modern, concerning the natural laws were applied scientists. He felt that all the speeches that had been made were in the nature of sermons to the converted. They were all in agreement with the main facts in Dr. Longmuir's remarks. The progress that had been made in science in the last decade was remarkable, and if there was greater unity with the craftsmen it would be put to better use.

LANCASHIRE BRANCH.

The annual dinner of the Lancashire Branch of the Institution was held on January 17. Mr. S. Roe, the president of the Branch, presided, and among the guests were Mr. Marshall Stevens, M.P., Alderman Kay, ex-Lord Mayor of Manchester, and Mr. C. Day (Messrs. Mirrlees, Bickerton & Day).

In proposing the toast of "Greater Manchester," MR. MARSHALL STEVENS, M.P., pointed out that the district included in this phrase extended far beyond the municipal boundaries, and was the greatest industrial area in the world. The cotton industry overshadowed other industries, which, themselves, were of the greatest importance and of astonishing variety. Some of them had been established since the making of the Ship Canal, an achievement they were all justly proud of, the greatest monument in the world to private enterprise.

ALDERMAN KAY, in responding, said in the future the Manchester authority would control the water supply of something like 75 per cent. of the population of Lancashire. The union of Manchester with Salford was almost an accomplished fact.

MR. KEY proposed the toast of "The Institution of British Foundrymen." He said it was the only Institution connected with the foundry industry that catered for the intellectual advancement of the foundryman. Founded in 1904, it had progressed in a way which compared favourably with that of any similar institution, the membership being 1,750. If the Institution had not been established foundrymen would have been less wise in regard to their trade than they were now. It had brought the trade more into the limelight, and raised it to a higher level in the estimation of the public. Valuable work had been done by it during the war, and the time had now come to organise a system of scientific research. The Government was prepared to subsidise such a system if anybody was willing to undertake the responsibility, and the Institution has appointed a Committee to consider the matter. The idea was to form a research laboratory and combine with it an information bureau.

MR. W. H. SHERBURN, in replying, said that before the Institution was formed the foundryman was in an invidious position. He felt he was as good a craftsman as any other man, but he did not get the recognition that others did, and he was reproached for not working upon scientific lines instead of proceeding by rule-of-thumb. But there was always a good deal of independence about the foundryman. Even if the work was done by rule-of-thumb some of it was very good work; and while recognising the great strides which had been made in the diffusion and application of scientific knowledge, he questioned whether the present generation had not lost something which was more important. In the old times master and men worked together in the foundry; even if the master was away he knew that the men were conscious of the place they held, and the individual interests of each were merged in the common interest. It was necessary to study the science of humanity and learn how to get on with each other.

MR. OLIVER STUBBS, in proposing the toast of "The Visitors," said he drew the attention of Mr. Day, as a leading member of the technical section of the educational authority, to the unsatisfactory way in which the foundry trade was treated in connection with the Manchester Municipal College of Technology. An important city like Manchester should recognise the need for the education of the younger members of the foundry industry. In order to get apprentices the business must be made worth knowing. If that was done, and they were backed up by the educational authority so that a boy of 14 or 15 could be properly trained, there would be no necessity to go to any of their competitors in other lands for any instruction in the foundry business. The conditions in the foundry must be vastly improved.

MR. C. DAY said, in the foundry trade, as in others, when help was needed, the first thing to do was to help themselves. The deficiencies in the foundry department at the College of Technology were due to the lack of applications for facilities to study in that department, but the College was now overcrowded, and plans were being made for an extension. An important feature of any extention would be a foundry department. In establishing the Institution the foundrymen showed what they aimed to achieve in the future, and if they gave their support to the College of Technology the College were most anxious to help them. A few weeks ago he was at a meeting where the manager of a Labour Exchange made his report. A striking feature of that report was that for some trades the number of boys who desired to enter certain trades as apprentices far exceeded the number of vacancies, while in other trades the posi-

tion was quite reversed, the vacancies exceeding the number of applicants. That was so with the foundry trade. The boy, either themselves or by the advice of their parents, sought employment in other trades. It was necessary to study the conditions under which the men worked, and the conditions must be made attractive. It was not a matter of money but a matter of amenities. The works should become a centre of social life as well as of works. It should not be a matter of going to work in a place and being glad to get out of it and away from it. Shortage of labour was going to be emphasised more and more. Therefore a very important factor in the foundry trade of the future must be the development of improved methods, less laborious methods, to modernise the industry, and get the maximum of production with the minimum of physical labour.

He was one of a Commission which visited the engineering works in the occupied area of Germany, and he was expressing the carefully considered opinion of the whole of the Commission, when he said that in the average condition of the works, the average production per man, the average organisation and engineering skill in those works was behind that of the similar works in Great Britain. This country was ahead in many respects. In particular he emphasised the question of education. The system which prevailed in Germany was that the educated class was a privileged special class. Practically the occupants of all the superior positions—foundry managers, managers of engineering works and the like—were selected from the University-trained men. They did not seek to establish methods of educating the ordinary apprentice, the workman's son. What was the effect of it? The average boy never had a chance of advancing. That was the greatest curse a country had. In this country nearly all the managers and principals had risen from the ranks of the ordinary apprentices; they profited by the facilities for elementary education, evening classes, scholarships, and so on. He hoped that in the foundry trade, as in other trades, there would be a raising of the standard of the environment in which they had to work.

NICKEL-IRON ACCUMULATORS.—Arrangements have been made by Batteries, Limited, Redditch, to manufacture in this country the nickel-iron-alkaline electric accumulator for which Dr. V. Jungner, a Swede, took out his first patent in 1899, and which began to be manufactured on a large scale by a Swedish company about eight years ago. The active material of the positive electrode is nickel hydroxide, mixed with other ingredients to increase the conductivity. This composition is formed into briquettes which are fed between two inactive perforated nickelled steel strips. These strips are cut up into suitable sizes, folded together, and fitted into a steel frame, the complete electrode being then put through a rolling process to ensure perfect contact between the active material and the steel strips. At the same time grooves are formed on the plate to keep the Para rubber insulators in position. The negative electrodes are constructed in the same way, the active material being iron oxide specially prepared and mixed with other materials to prevent self-discharge of the cell. The assembled positive and negative plates are immersed in a solution consisting chiefly of potassium hydrate, contained in a steel cell with brazed joints. The batteries are made in two types, one for a normal slow discharge in eight hours, and the other for rapid discharge in four hours. The average working voltage is 1.2 volt; it drops slightly during the first 15 min. of discharge and then remains practically constant till the cell is completely discharged.

Materials and Methods Used in the Manufacture of Enamelled Cast-Iron Wares.*

By Homer F. Staley.

Very little information has been published relating to the technology of enamelling cast-iron articles. On this account the comprehensive treatise of this subject by the author is especially welcome.

The Paper deals particularly with the coating of cast iron with white vitreous enamels by the American or dry-powder process. In this method of manufacture the thoroughly cleaned castings are painted with a suspension in water of powdered glass, clay and other materials. This suspension is known as the ground coat. The castings are then heated until the ground coat is thoroughly fused, forming an extremely thin layer of transparent glass on the castings. The ware is then withdrawn from the furnace and immediately coated by means of long-handled sieves with a layer of white, opaque, powdered glass, known as the cover coat enamel. Next the castings are returned to the furnace, and in a couple of minutes the cover coat enamel fuses to a smooth layer. Two such layers of cover coat enamel are usually applied, giving a total thickness of from 1-32 to 1-16 of an inch. The Paper does not discuss the enamelling of cast iron with wet coat cover enamels.

Several sections are devoted to a discussion of the preparation and testing of the various chemicals and minerals used in compounding enamels and to the effect each of these has on the physical and chemical properties of enamels. The methods employed in making and cleaning the castings are described in detail, beginning with construction of patterns and ending with sand blasting and polishing. The methods and equipment, including furnaces, used in preparing enamels and applying them to castings are covered in two sections. Sections are devoted to the control of the lustre of enamels, the cause and control of crazing, and to the methods to be used in avoiding blisters, pin holes and other minor defects. Typical formulas are given for ground coat enamels, cover coat enamels containing oxide of tin, and for those containing antimony compounds as the opacifying agent. These formulas are each stated in terms of raw batch for 1,000 lbs. melted enamel, of percentage composition and of empirical chemical formula. The calculations involved in arriving at each form of expression are explained in detail.

The London offices of Marshall, Sons & Company, Limited, Britannia Ironworks, Gainsborough, have been removed to 3, London Wall Buildings (2nd floor), London, E.C.2.

SCIENCE AND INDUSTRY.—Signs are not wanting that the value of science to industry is becoming more widely recognised by employers, and numerous firms have made arrangements for the scientific instruction of their employees. A new departure in this direction has been inaugurated by the Anglo-Mexican Petroleum Company, who have arranged for the delivery of ten lectures to the staff by Mr. C. R. Darling, Lecturer in Physics, Finsbury Technical College, on the commercial applications of Physics. These lectures are intended to form a groundwork for specialised lectures to be given by experts connected with the company, and to furnish a broad outlook on the subject of the application of science to industry. A lecture-room has been provided on the company's premises at 16, Finsbury Circus, E.C., furnished with the necessary fittings for experimental demonstrations. The provision of a connected course of lectures of this kind is a novel feature, and should prove a valuable aid to any scheme of commercial scientific education.

* Abstract from U.S. Bureau of Standards, Tech. Paper No. 142.

The Use of Permanent Moulds for Radiator Castings.

The American "Foundry" describes a complete plant for the production of radiator sections in permanent moulds. The inventor (Mr. C. P. Herd, Kewanee, Ill.) states that his process will overcome the difficulties found in moulding with sand, eliminate the necessity of providing skilled labour and increase production. To demonstrate his ideas, he has prepared plans and estimates for a foundry capable of turning out approximately 10,000,000 feet of radiation a year. This is to be accomplished by the aid of 28 moulding stands and a total operating force of 50 men.

In this ideal foundry there will be no sand, therefore, there will be no need of sand handling equipment, no overhead machinery, and no store room of belts, gears, pulleys, and other expensive repair parts.

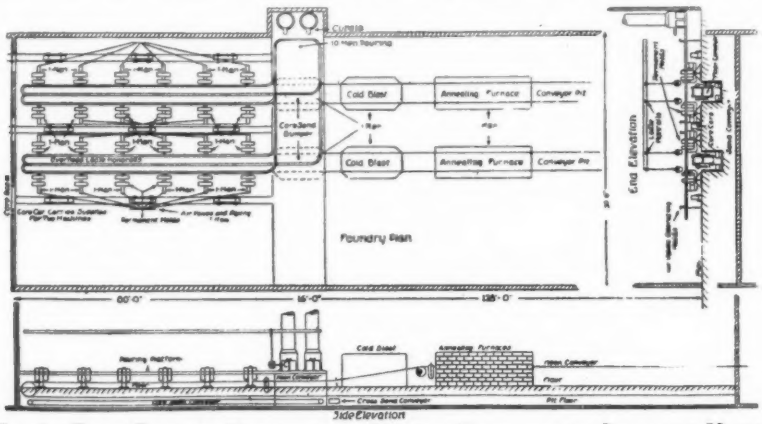

FIG. 1.—FLOOR PLAN AND ELEVATION OF A FOUNDRY EQUIPPED WITH PERMANENT MOULDS FOR RADIATOR CASTING.

In this ideal foundry there will be no sand, therefore, there will be no need of sand handling equipment, no overhead machinery, and no store room of belts, gears, pulleys, and other expensive repair parts.

which will carry it in turn to the core sand knocker, the cold blast, and the annealing furnace. The mould will remain open four minutes, giving him ample time to perform these duties and also set the core for the next casting.

One air valve operator will have charge of six machines. He will be located in a pulpit high enough to oversee the different operations. After each core is set he will close the mould and swing it to a perpendicular position ready for pouring; after the mould has been poured, he will open it to remove the casting and prepare it for the next one.

Ten men will be required to pour the moulds. Each man in turn will run a ladle hanging from a monorail up to the cupola, fill it with iron and pour such moulds as he is instructed.

There are a number of details to be worked out yet but most of the operations are definitely fixed.

In sand moulds for radiators, the chaplet is rammed up with the pattern and therefore the head appears

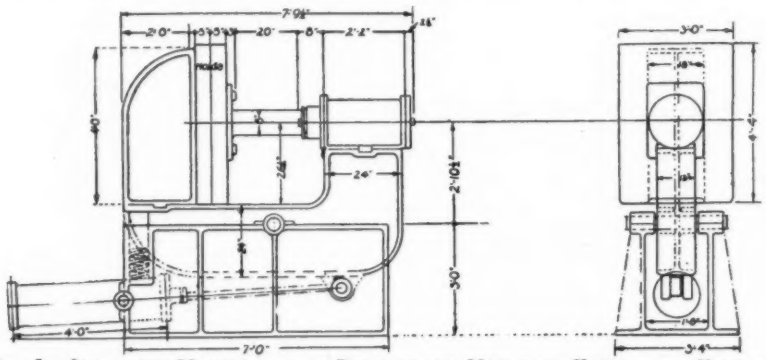

FIG. 2.—ONE OF THE MACHINES WHICH PICKS UP THE MOULD AND HOLDS IT IN A VERTICAL POSITION FOR POURING.

The sequence of operations from the coreroom to the test room will be as follows: The cores will be loaded on cars holding enough for a day's run and placed conveniently for the men closing the moulds. Extra cars can be loaded one day for the next day's run, and placed in position during the night.

It is proposed to have one man for each machine. His duties will be to set cores and remove the casting after the mould is poured. Having knocked off the gates, he will hang the casting on a hook conveyor outside the casting. It must be chipped off, and if the stem has not fused with the heat of the molten iron, a leak develops which requires calking. With the permanent mould, the position of the chaplet will be reversed, the head will be in the core and remain on the inside of the casting. Furthermore, it is said lighter chaplets will suffice because the castings will be poured in a vertical position.

[N.B.—Sand would appear to be used for the cores. —ED.]

Atomic Structure of Metals in Solid Solution.

By A. L. Feild.*

The industrial importance of solid solution alloys is too great to be comprehended fully unless consideration is given to the fact that hardened steel and the majority of the alloy steels, of which tungsten, nickel and manganese steels are familiar examples, as well as the common electrical resistance alloys, such as nichrome, manganin and constantan, all belong to this same general class. Any theory, therefore, which offers a reasonable explanation of the mechanism by which the physical properties of these alloys are caused to depart to so great an extent from those of their constituents would appear to be worthy of consideration.

Solid Solutions Have High Specific Resistance.

The relatively high resistance of alloys which consist of two or more metals in solid solution has not heretofore received a satisfactory explanation. When, for instance, increasing amounts of gold are added to silver to form a series of solid solution alloys, the curve expressing the specific resistance as a function of the

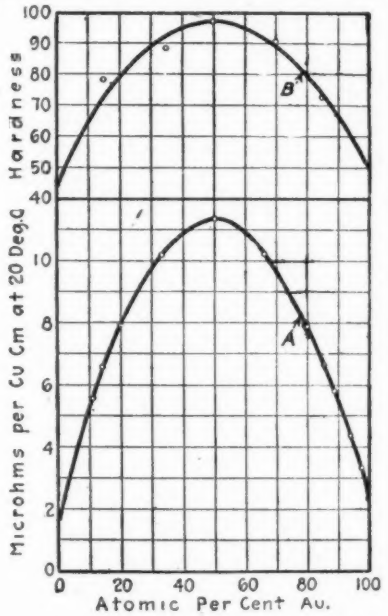

Fig. 1.—Composition Curve of Ag-Au Alloys, from Measurements by Matthiessen.

A—Specific resistance—composition curve of Ag-Au Alloys. B—Hardness composition curve of Ag-Au Alloys.

composition rises sharply from the value corresponding to pure silver to a maximum and drops sharply to the value corresponding to pure gold (see Fig. 1, curve *A*). On the other hand, for two metals, such as lead and tin, which form a strictly eutectiferous series of alloys, the specific resistance composition curve is very nearly a straight line.

The author studies at some length the property of electrical conductivity of solid solutions and the electronic theory of conduction. Consideration is given to the Wiederman-Franz-Lorenz equation, which states in effect that the ratio of thermal to electrical conductivity multiplied by the absolute temperature is a constant for all metals. It is pointed out that this law holds good for only a narrow range above the ordinary room temperature.

The discontinuity of the electrical properties on the melting and solidification respectively are considered, and as a result of the evidence brought forward the author concludes that the high electrical resistance of solid solution alloys due to the retention in the solid state of the atomic structure of the liquid state would seem to establish the fact that the hardening of pure metals as well as the increased hardness of solid solutions over that of the pure components is due to the presence of amorphous solid metal. Hardening occurs when the metal is sheared beyond the elastic limit, and presumably during the time when flow occurs a certain portion of the metal is actually in the liquid state. In the case of such metals as lead, thallium and tin the transformation of the amorphous solid metal resulting from the rapid freezing of the liquid metal to the original crystalline metal occurs very rapidly and is completed within a short time. In the case of copper and nickel, for instance, the transformation of the amorphous phase to the crystalline is not complete. A dynamic equilibrium is finally set up during continuous cold working whereby the same amount of amorphous metal is converted to crystalline as is formed by the shearing processes.

It is unnecessary to call attention to the need of more complete data on the electrical resistance in the liquid state of those metals which are able to form solid solution alloys, and also on the electrical resistance of their different alloys. Particularly in the case of Pt, Pd, Fe, Cr, Mn, Bi and Sb this information would be of much value in obtaining additional confirmation for the theory herein advanced. In the case of the metals Fe, Mn, Cr, V, Ti and Si experimental determinations of the specific resistance in the liquid state over a range of temperature would probably yield information of very great importance to the science of metallurgy and metallography, especially in so far as iron and steel is concerned. The use of electrical methods for investigating the properties of metals is older than either the thermal or the microscopic method. Assuming that we are able to grasp completely the essential principles underlying the electrical properties of metals—and it is believed that the theory advanced in the present Paper is a step in the right direction—it can be predicted that the electrical method of examination will eventually become a very powerful instrument of industrial research and control, possessing also enormous possibilities from the purely scientific standpoint.

* Abstracted from Metallurgical and Chemical Engineering.

ALUMINIUM SOLDER. — "Elektroindustrie" states that a new aluminium solder has been discovered by K. Binggeli, of Bern, that enables very strong joints to be made, and renders construction of aluminium tins for foodstuffs possible. The electric resistance of joints made by the process is exceedingly low. Tensile tests made by the Swiss National Testing Bureau show that rods joined with the solder break outside the joints and that the strength of the joints exceeds 1,500 kg. per sq. cm.

SHALE AS BLAST-FURNACE FUEL.—Deposits of oil shale have recently been discovered in the province of Hanover, which are said to open up new prospects for the supply of fuel to blast furnaces. In Sweden oil shale has been successfully used in pig-iron making, the furnaces being first heated with coal, but once ignited the shale burns much longer and leaves less ash than ordinary coal. In view of the present great scarcity of skilled miners in Germany, the comparatively easy mining of oil shale is a great advantage, as it is mined in the open with the help of dredging machines and unskilled labour.

XUM

Difficulties in Making Steel Castings.*

By F. Darley.†

Many people interested in the manufacture of castings find it difficult to understand the great difference there is between the making of iron and steel castings. The chief difference arises from the difference in contraction. The average rate of contraction of cast-iron is 1-10 of an in. per ft., which is considerably less than that of the different varieties of steel.

Steel suitable for magnet castings contracts 5-32 in. per ft.; ordinary carbon steel castings contract 7-32 in. per ft.; manganese steel castings contract 9-32 in. per ft. The values of contraction must not be taken as absolute, since there are so many factors affecting contraction, as, for example, the casting temperature of the metal and the design of the casting.

The first question that calls for special consideration, arising out of the casting temperature, is that of piping. We will consider that of an ordinary steel ingot, cast in an iron mould on end; either square, octagon, rectangular or round, cast from the top.

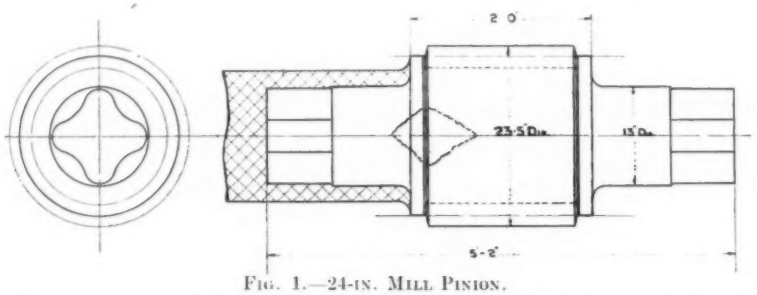

Fig. 1.—24-in. Mill Pinion.

Shrinkage begins to take place immediately after casting, and providing no artificial means be adopted to keep the top of the ingot hot, the steel will set round the outside, where it comes in contact with the mould first, and on account of the whole mass cooling gradually from the outside, while the inside or middle is still liquid. The result will be that the molten portion in the centre will feed down, while the outside cools quickly and does not settle down at all, thus causing the ingot to be piped down the centre. So long as there is any fluidity left in the ingot, it will feed down to the bottom by force of gravity, but in a few hours' time—which depends entirely on the area or size of the ingot—the metal sets or freezes at the top, when it can no longer feed down into the mass. The shrinkage, however, still goes on, and must continue until the whole mass is cool.

Many ingots are piped about $\frac{1}{3}$ of their length. It will be perceived how difficult it is to feed a taper or parallel block cast on end. It is much more difficult to feed a steel casting of irregular thickness. Take, for example, a rolling mill pinion, Fig. 1, with a neck and wobbler on each end. It is almost impossible to make this casting in steel, with both ends cast to shape, owing to the body (the thick part) keeping fluid after the top neck and wobbler (thin parts) have frozen. The bottom end and neck, also the bottom part of the body, will be solid. The top end and neck will be solid, if it has a head on, but piping will take place at the top part of the body and run towards the root of the neck, and so cause a serious weakness, where strength is required

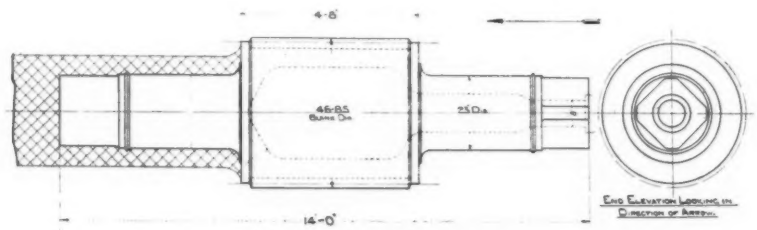

Fig. 2.—40-in. Mill Pinion.

If we could arrange for the piping to take place in the centre of the body it would be all right. The writer believes that someone has tried the experiment of casting them on end, then turned over from end to end a few times during cooling, so as to feed them first one end and then the other, from the centre of the body; but he does not think the experiment was successful. The only safe way, is to cast sufficient metal on the diameter of the top end to feed the casting properly, and then machine the wobbler and neck out of the solid. Another method is to core out the centre, a method which is very good up to a certain diameter.

In the first place, the core cannot be carried up

* Read before the Institute of British Foundrymen.
† Foundry Manager, Messrs. Thos. Firth and Sons, Limited.

through the top end of the casting, or it encroaches on the area required for feeding. The better plan is to core out, as shown in the sketch; then the core must be bolted down, also the vents must be taken out through the bottom. The writer had an experience of the undesirability of this method some time ago with a large pinion cast in this manner (see Fig. 2). It was of large dimensions, and moulded on end. A suitable core was made, vented, and bolted down to the bottom of the mould. The casting was made, and to all appearance it was a success, but some few hours later a disturbance was seen to take place round the vicinity of the head. It was not thought much of at the time; the casting was annealed and fettled, but when we came to the core we found it very hard; in fact, we found the part round the bottom

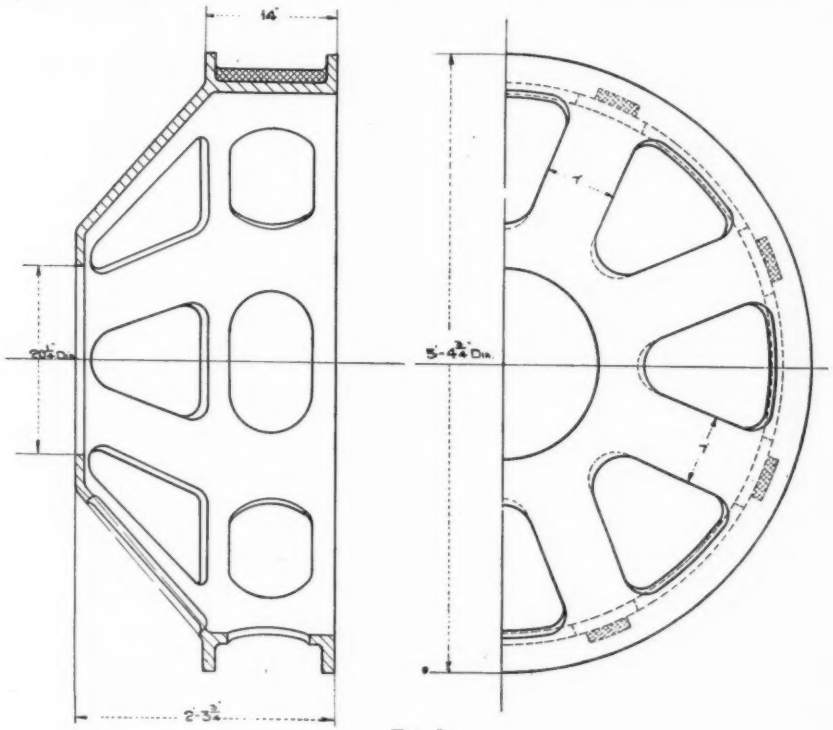

FIG. 3.

neck was fused up solid. We did not expect to get much of the core out, nor were we much concerned, as it was of no moment whether we got it out or not, so long as the casting was sound.

The casting was sent to the machine shop to be turned down to the required diameter. The bottom neck and body were all right, but the top neck had about 4 in. aside added for feeding purposes, and when this was turned out to within 1 in. of the required diameter, there was discovered some straight gas or vent holes, which on being traced came straight through the head from the centre of the core. These holes, we considered, were caused by the gas from the core forcing its way through the plastic steel, after the bottom vents were fused up. This suggested that it was not practical to expect a core of so small a diameter to stand the heat and pressure of such a mass of molten steel.

The difficulty of making solid castings applies in a more or less degree to any casting where the thick parts, owing to the peculiar design of the job, cannot be properly fed by a large head (see Fig. 3). It is impossible to make perfect steel castings with thick parts which have to be run through a thin wall. Unless it is possible to put a head on the thick part, piping is bound to occur. It is sometimes possible to feed a thick part by adding a piece, as shown in sketch, which may be cut out by an oxy-acetylene flame; or, if not in the way of anything, this feeding piece may be left in.

If engineers would consult the practical foundryman when designing castings, many difficulties could be avoided and others readily overcome by modifying designs so as to allow placing the feeding head in the right place. In the absence of such consultations, it often happens that if we put the head in the right place for feeding purposes, then it would be impossible to cut it off, because of some intervening bracket or projection, which could, by a little thought, have been placed in another position.

The foreman also has to consider the size and shape of head, also what effect the head will have on the casting, as regards resistance to contraction. He looks round the job and decides which is the correct position to place the head to feed the casting, but there is something else to consider. Although he is convinced that the place decided on is the best place to feed from, it may cause the casting to pull at the place which is still molten

or in a soft state. In some cases it is difficult to decide which is the less evil to risk, a piped casting or a pulled one. As already shown, the contraction of steel is responsible for both the piping and the pulling of castings, and it is not possible to guarantee that castings of large dimensions will contract exactly according to allowance, on account of not being able to take the temperature when cast.

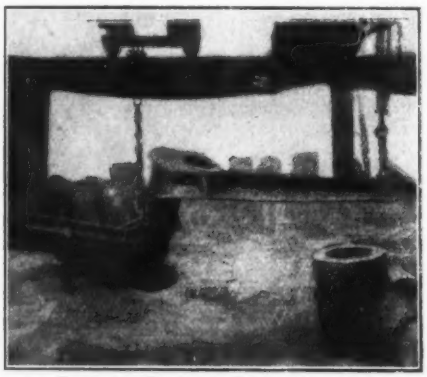

FIG. 4.—SHOWING PART OF CAST-STEEL STEM FRAME FOR BATTLESHIP. CASTING WEIGHT 24 TONS 10 CWT.

In the casting of stem pieces or stern frames for ships, castings sometimes 40 ft. long, the contraction in length is about 8 in. (see Fig. 4). It is needful in these cases to construct the mould so that the casting can be liberated at different stages to allow it to contract, or it will be liable to pull itself to pieces, especially where there are thick places or cross ribs. This is on account of the metal keeping fluid longest in the thickest parts. The time when a pull takes place is when the steel is in a plastic state, that is, going from fluid to solid; never after freezing.

The avoidance of pulling in castings has been, and still is, a very serious question in the steel foundry. One method adopted by foundrymen is to cast thin brackets across the parts likely to pull. The idea is that the bracket, being thinner than the casting, will cool first, and thereby hold the casting from pulling. In some cases brackets prove very successful, but not always, for they sometimes cause a casting to pull by not allowing it to contract. The brackets cooling first, contract first, and when the casting round about the brackets, which has kept molten longer on account of its greater thickness, cannot contract in consequence of the resistance of the brackets, it pulls, sometimes between every bracket. Brackets are all right when used very carefully, but the writer's opinion is that there are more waster castings made by being over-bracketed than under-bracketed.

FIG. 5.

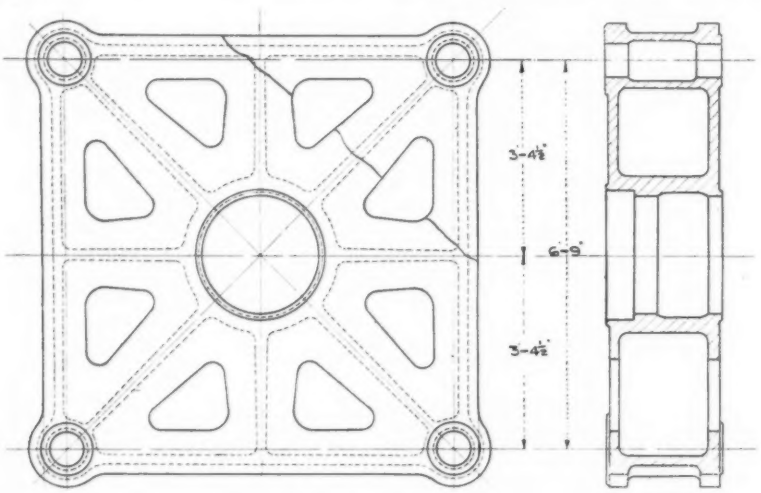

FIG. 6.

The breaking of castings by uneven contraction during cooling causes much trouble. The safest way with most ordinary carbon steel castings is to leave them in the moulds until quite

cool, but owing to limited floor space, this is not always possible. The next best method is to lift the casting from the mould as soon as possible, and get an air passage through the inside cores; then cover the outside of the casting as much as possible, and so cause the inside to cool at the same rate as the outside. The danger point, when a casting is liable to break, is when it is going from luke-warm to cold; they very rarely break before they are cold enough to put your hand on without burning.

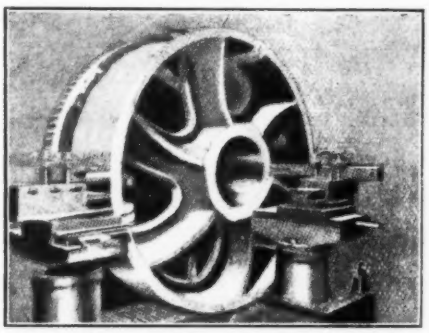

FIG. 7.—TURBINE WHEEL WEIGHING 18 TONS.

Nickel-chrome-steel castings of large size should not be allowed to go cold in the mould, but should be lifted from the mould as soon as possible, and placed in an annealing furnace, heated to about 500 deg., then heated slowly up to about 650 deg., and then allowed to cool slowly in the furnace, after which they can be safely fettled and the heads removed before final annealing.

The castings most liable to break are wheels—large wheels with arms cast in, or anything in the shape of a large frame similar to Figs. 5 and 6 or hydraulic pressheads, supported by diagonal stays which are pulling against each other when cooling. This is caused by the outside cooling first and resisting the contraction of the internal parts.

Some years ago we made some very large turbine wheels (Fig. 7), about 10 ft. 6 in. diameter × 2 ft. 6 in. on the face, with a heavy boss and arms cast in, weighing about 18 tons each. We cast the first, and as soon as it was safe we lifted it from the mould, and put it into an annealing furnace. A great deal of sand from the mould adhered to the casting in lifting it from the mould, and was on it throughout its treatment in the furnace. The casting was in the furnace, annealing and cooling, about four weeks. Then it was taken out apparently cold. But after being in the shop three days, and partly fettled, it flew to pieces. We had four of these wheels to make, and that was the start. From that experience we decided that it was not safe to cast another on the same lines.

What is considered a safe way—in fact, the safest way—with a wheel casting of these large dimensions, is to split the boss between alternate arms and fill in the splits with soft metal and hoop, afterwards with forged steel hoops. This, however, was not permissible in the turbine wheels, as they required to be shrunk on the shaft. We, therefore, suggested splitting the rim between alternate arms, which we considered would have the same effect as splitting the boss in allowing the arms to contract. This suggestion was accepted, so we split the rim in three places, with cores $1\frac{3}{8}$ in. thick, making provision for machining out the splits, and fitting in steel plates and bolting them together, so as to form a complete rim equal to a rim cast solid. Some time after being cast,

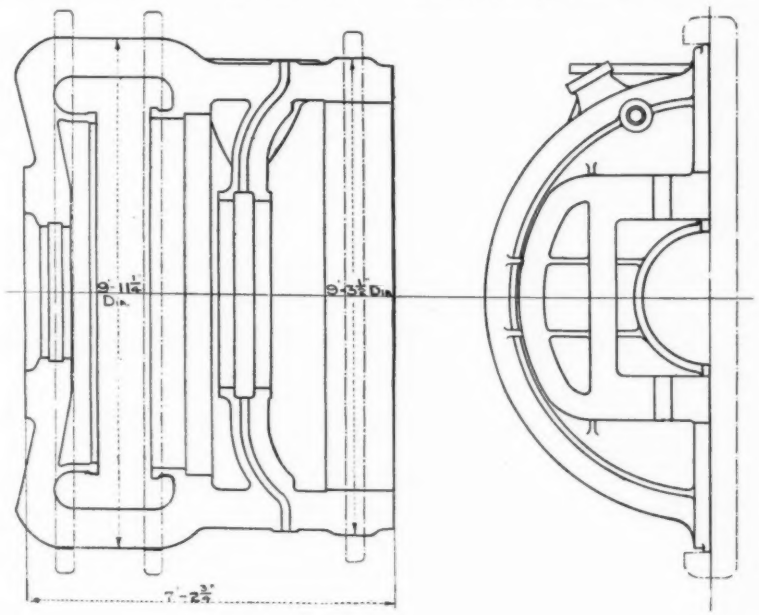

FIG. 8.

the top part of the mould was lifted off the casting, and as the wheel cooled, the splits began to open wider, until they measured from $2\frac{1}{4}$ in. to $2\frac{3}{4}$ in., instead of the original $1\frac{3}{8}$ in. arranged for. This was one of the most instructive examples we could have had of the process and effects of steel contractions in large castings. The rim was the thinnest part of the casting, and therefore cooled quickest, and being split was free to close in as the boss and arms cooled afterwards, until the splits came to be $1\frac{1}{2}$ in. to $1\frac{5}{8}$ in. wide, instead of the original $1\frac{3}{8}$ in., and this slight difference between the actual and calculated contraction would probably be caused by the resistance of the arm cores.

Let us now consider for a few minutes the strain a casting of this class must be subject to, if cast without splits, if it does not break. The contraction would inevitably take place, just in the same manner, the rim first, which would probably stretch so much. This would put a compression on the arms, and when the rim had practically finished contracting, the arms and boss would continue to contract until cold—some considerable time after the rim. This uneven cooling would set up very severe tension on the arms, so much, indeed, that a slight shock, such as a blow from a hammer or a bump by some other casting would cause one or more of the arms to break.

It is very gratifying to be able to state that our success in the experiment with split rims became widely known, and within a period of three or six months following, the method was adopted by the Admiralty and all the leading marine engineers. In fact, I do not think that anyone asked for a turbine wheel over 5 ft. 6 in. diameter to be cast without being split in the rim, within twelve months after we had made our first one.

In the early days of cast-steel turbine wheels there were many difficulties to be dealt with, both in the foundry and the machine shops. Several were broken during the process of shrinking on the drum and being shrunk on the shaft. One case, in which I was personally interested, was a wheel about 8 ft. 6 in. diameter, cast solid without splits in the rim. This wheel had been machined ready for shrinking on to the shaft. It was heated up to about 600 deg. F., to expand the wheel for the purpose, with, apparently, very satisfactory results, so far as we could see after it had cooled down. The drum into which the blades are fitted was then heated and shrunk on to the wheel. Some hours afterwards, during the final cooling, two arms of the wheel broke. It appears that the cause of this breakage was that the cooling of the wheel when being shrunk on the shaft was uneven. The rim being the outside portion, and more exposed to the air and also of thinner section, would contract first and put tension on the rim, and compression on the arms. After the rim had finished contracting the arms and boss would still be cooling, and so put a tension on the arms. This operation would put the whole casting under a severe strain. The heat of the drum on being placed on the wheel, again caused the rim to expand and so put more tension on the arms, causing them to break. I am confirmed in my view by the fact that the fracture remained open about 3-16 in. After the arms had been cut out, the fracture when examined was found to be practically perfect.

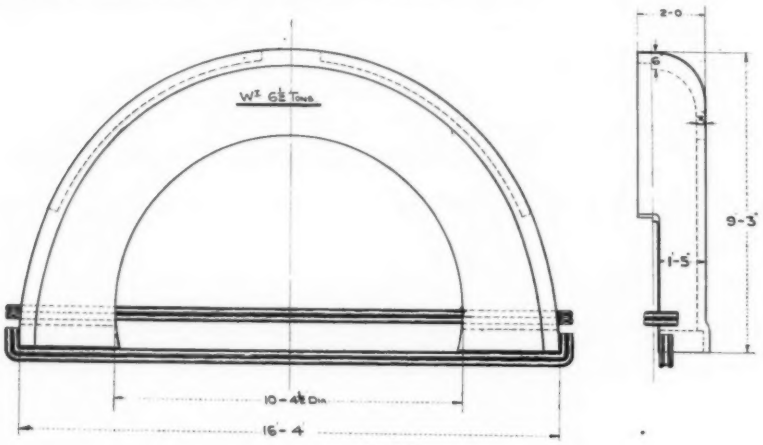

FIG. 9.

I remember a firm making a spur wheel about 12 ft. diameter, with arms in, cast in halves. Both moulds were made by the same workman, and measured the same diameter. They were both cast from the same ladleful of steel. In due course the castings were measured, and to our great surprise and disappointment the half wheel cast first was $\frac{3}{8}$ in. smaller than the other half. This experience sustains my view, that contraction is greatest when the steel is hottest at the time of casting.

In further support of this view, I may quote a further experience: We made a spur rim, about 23 ft. diameter, 15 in. face, of a rather light section, cast in one piece, to be cut up into ten segments—teeth were cast in with an allowance for cutting. I asked our steel manager to give us the steel as hot as he could, to ensure the casting being properly run. The mould was carefully measured up after drying, and the diameter was found correct, allowing 7-32 in. per foot for contraction. The job was cast, and in due time measured up, when it was found to be $1\frac{3}{8}$ in. too small, having contracted nearly 9-32 in. per foot, which meant that each segment was about 7-16 in. too short. As

this was intended to replace an existing wheel which was also made up by segments bolted on the rim of a flywheel, our customers told us it would not do, as they could not alter the diameter, therefore we must make another. But, seeing that the casting was a very good and sound one, and knowing the uncertainty there was of guaranteeing the correct diameter if we made another one, I decided to try to make this one correct. I had a cast-iron

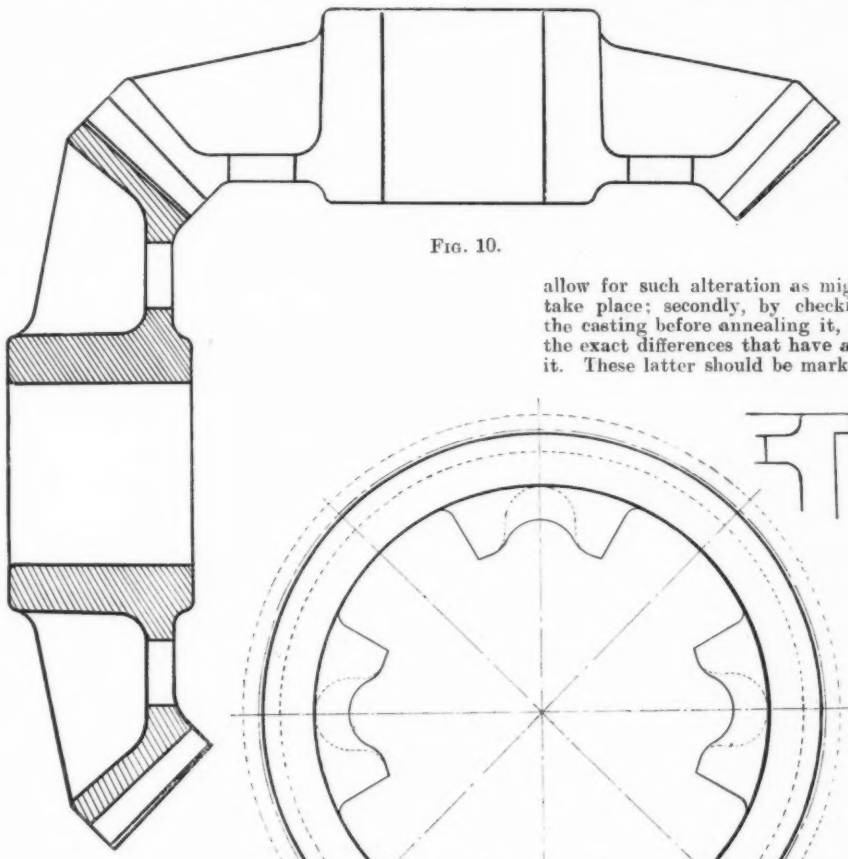

FIG. 10.

block made to the correct radius of the inside of the rim, and a swage tool made to fit in the space of one tooth. Then we heated the segments one end at a time, and drew them out under the press when heated. I found that they had expanded, which made it very difficult to measure the correct length. Anyhow I allowed for this, and eventually got each segment drawn out to the correct length. The wheel was machined and duly delivered to our customers, and is at work to-day. I merely state this case as an example of what it is possible to do with a steel casting.

Another problem with which the foundryman has to deal is the maintaining of the correct shape of large castings, for ships and engines, during the process of cooling and annealing. This problem can often be solved by following the dictates of past experience. First by making the pattern so as to allow for such alteration as might be expected to take place; secondly, by checking over carefully the casting before annealing it, and so finding out the exact differences that have already occurred in it. These latter should be marked on the casting,

FIG. 11.

which should then be placed in the annealing furnace on to a carefully-prepared bed, suitably packed, so that when it becomes hot it will settle down on to the packing and so correct the deformities of its previous cooling. Sometimes it is found needful to place weights on the high parts to ensure their correction. By this process is avoided the setting up of any internal strain, which would be liable to occur by local heating, *i.e.*, by heating

only the parts affected. When the casting is out of shape and it is not practicable to weight it in the furnace, it becomes needful to resort to other methods, such as locally heating the parts in question, then using screws or hydraulic jacks to push out the parts or screw chains to pull the parts in, as the case may need.

Some time ago we had a turbine-cylinder casing, in halves, which came out of the mould about ¾-in. too wide across the joint. It was heated the full length across the crown and then we attempted to pull it in with screw chains, but we could not move it because of the ribs, feet, etc. This method having failed, we next placed the casting in an annealing furnace, and placed three strong cramps across the joint from side to side (Fig. 8). The joint and cramps were placed on the furnace bottom, and the cramps covered with about 6 in. deep of sand to protect them from being heated, and so keep them from expanding with the casting. The remainder of the casting was exposed to the heat, which was bound to expand, and would either close in the casting or break the cramps. The cramps did not break, but the expansion of exposed parts of the casting forced the joint into its proper shape, and the treatment proved perfectly successful. We have used this method on other jobs since, with equal success.

A short time ago we had a large roof plate to make in nickel steel (Fig. 9). This plate was 4 in. thick, with dish sides, running out to 6 in. thick, and about 14 ft. wide, with a 10-ft. diameter hole cast in. The roof plates were made in halves and jointed across the hole. After having them oil-treated, we experienced some difficulty in keeping both halves the correct width. We took one part to the armour-plate bending press to try and bring it into proper shape, but we found that it was a very dangerous and unsatisfactory job, because the packings flew out. We were not allowed to heat it up to more than 100 deg. C., and under that restriction it could not be done under the press. Later on we had another roof plate which was 1¼ in. too wide. It should be explained that in the oil-treatment of castings of this class one cannot depend on two castings acting alike. Owing to that uncertainty of results in the oil-treatment we decided to try the cramp method. Two powerful cramps were made out of double-headed rails and fixed on the casting, making due allowance for the correct expansion of the casting when heated to the required temperature for oil-treating. We then placed the casting in an annealing furnace and covered up the cramps with bricks and sand. We gradually heated the casting up to the right temperature, and as the casting expanded the cramps pulled in the part too widely open. The casting was lifted from the furnace and re-oil-treated. When it contracted in cooling the cramps fell off, and when we afterwards measured the casting up, to our great satisfaction the measurements were correct. We had brought in the distance of the parts exactly 1¼ in.

Some years ago we had some large bevel wheels to make (Fig. 10). We were very particular about setting them out correctly, also in fixing the blocks on the moulding machine to the correct bevel. The writer had occasion to see some of the wheels geared up, and to his great surprise found that they did not gear up correctly in the bevel. In every case they were out of gear at the large end of the teeth. At first it was thought that the moulding machine must have been out of truth in the slides, but on further examination it was found that the contraction was at fault. They had contracted more at the large end than at the small ends of the teeth—the difference being equal to $\frac{3}{8}$ in. in the diameter per foot of the width.

Large spur rims (Fig. 11), we also find, contract $\frac{1}{8}$ in. to 5-32 in. per foot of width, more at the top side than the bottom as cast; therefore, if the diameter is set to the correct contraction at the top, and an angle allowed of 5-32 in. per foot of width smaller at the bottom, other conditions being equal, the rim will come out correct.

A recent writer pointed out another method of dealing with distortion in castings, viz., that of making the patterns distorted the opposite way to that which it is expected the casting will go in cooling. There are many things to consider in a complicated casting that makes this suggestion impracticable. First, one cannot guarantee how far the casting will distort, owing to various circumstances which have to be considered, such as the construction of the mould, the fixing of core irons, and the temperature of the steel; second, it involves a great amount of work and many complications in making the patterns, especially if there are a lot of cores required, each part having to be distorted to suit the part where it fits.

The writer considers that the safest and most reliable method is to make the pattern as near as possible to what it is considered the correct contraction will be, in the light of previous experience on similar jobs. When and where the foreman moulder and the foreman pattern-maker work together in a mutual desire to achieve the biggest results, there are very few difficulties which are insurmountable in a steel foundry.

CO-OPERATION IN SCIENCE AND INDUSTRY.—An interesting experiment, on pioneer lines, has recently been inaugurated in Birmingham. A number of local manufacturers mainly using non-ferrous metals have formed themselves into a company, known as the Midland Laboratory Guild (on a non-profit or co-operative basis), and at King Alfred's Place chemical and physical laboratories have been established in order to bring science and technology into close application with industry. In this way the needs of the firms are met without the cost of installing separate laboratories in each individual works. The equipment provides for a complete chemical laboratory fitted with every necessary appliance, and affording special facilities for electro-chemical methods of analysis, as also for the examination of fuels and refractory materials, to which subjects considerable attention will be paid; a Metallographic Laboratory fitted with one of the latest and most complete types of photomicrographic apparatus, together with photographic dark room; a physical testing laboratory, the plant of which consists inter alia of a 25-ton Olsen testing machine with all modern fitments, Brinell hardness testing machine, Sankey bend testing apparatus, a 5-in. Drummond lathe, drilling machines, etc., and a pyrometric laboratory equipped for calibrating and testing thermo-electric pyrometers, effecting repairs and adjustments. The apparatus includes reflecting galvanometer and potentiometer, with a sensitivity of one-tenth-millionth of a volt. One room has been set apart as a scientific library. The laboratory is in charge of Mr. Seymour Pile, M.A. (Camb.), and there is a committee or board of directors, consisting of one member approved by each firm constituting the membership. This committee is responsible for the financial and commercial administration, but not for the scientific control.

The Use of Rotating Patterns in Pipe Moulding.

A recent issue of the "American Foundry" describes a new form of rotating pattern for use in pipe-moulding. This pattern, which is diagrammatically illustrated in the accompanying figures, is the invention of Mr. L. R. Lemoine, of Philadelphia.

Fig. 3 is a sectional elevation of the mould, Fig. 2 is a section through the pattern near the top of Fig. 3, while Fig. 1 is a section through the pattern on a lower portion of Fig. 3.

In the illustrations, *A* is a tubular ramming pattern having ramming ribs or cams, *B*, parallel with the axis

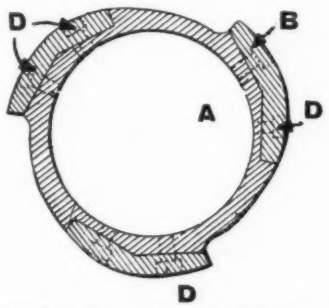

FIG. 1.—SECTION THROUGH LOWER PART OF PATTERN.

of the pattern. These are held in place by the screws. The pattern is moulded in the flask, *C*. The lower end of the pattern is centred and supported so that it can be rotated in the ramming seat member secured to the lower end of the flask by methods commonly used in making moulds of this character.

The bars or cams, *B*, are each formed to fit against tapered seats formed on the outer side of the pattern

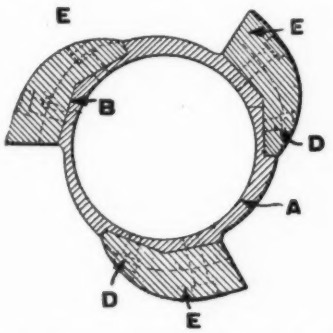

FIG. 2.—SECTION THROUGH UPPER PART OF PATTERN.

body. The forward edge of each cam bar is designed with reference to the direction of rotation of the pattern and fits against a radial shoulder at the forward edge of the corresponding seat. The convex surface of each cam bar is flush with the outer surface of the body, adjacent to the shoulder, and slopes away from the centre of the pattern body from the front to the rear edge of the cam bar.

The upper end of the flask, *C*, is flared outward to provide for the riser and runner basin of the pipe mould. The inventor states that his plans relate to the construction of that portion of the pattern used to form the inner wall of this part of the mould. To this end the cam bars, *B*, are stopped at approximately the level of the upper end of the unflared, cylindrical body portion of the mould cavity, but the tapered seats are continued and the shoulder is level above that of the upper end of the flask. Secured against each seat, above the corresponding cam bar, *B*, is a special set of cam bars, *E*, which are correctly contoured to form a cavity of the desired shape when the pattern is revolved

This portion of the interior mould surface comprises superimposed conical sections, F^1, F^2 *and* F^3, which are of different tapers and an upper cylindrical por-

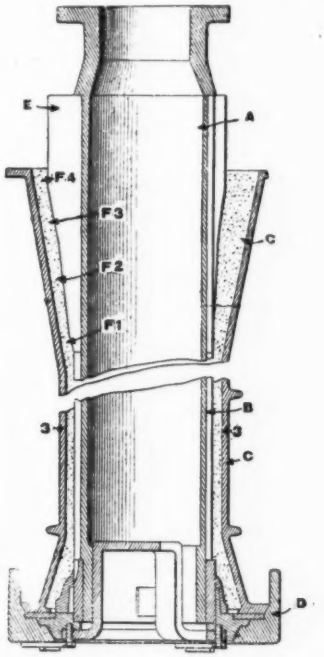

FIG. 3.—SECTION OF PIPE CASTING MOULD WITH PATTERN IN PLACE.

tion, F^4. The outer rear edges of the pattern cams, *E*, are formed to coincide with the surfaces F^1, F^2, F^3 and F^4. The convex outer surface of each cam bar, *E*, is shaped to run smoothly back to the outer edge of the corresponding shoulder, where it merges into an adjacent convex surface of the pattern body.

In operation, after the pattern is mounted in the flask and the space between the pattern and the flask filled with sand, the pattern is rotated to press the sand outwardly. This operation forms the sand into a compact mass, and at the same time outlines the desired mould cavity. As the pattern is rotated, sand is continually fed into the upper end of the flask until the mould is completely formed.

The cams, *E*, which form the riser and basin portion of the mould, it is pointed out, do not interfere with the downward feed of the sand between them while at the same time they serve properly to compact and shape the riser and basin portion of the mould.

XUM

Investigation of the Failure of a Cast-Steel Anchor.

An interesting investigation of a cast-steel anchor was described in *Stahl und Eisen*, March 27, 1919. The anchor failed to pass the prescribed drop test of the German Lloyd—a drop of 3½ metres (11.48 ft.) on a plate 500 mm. thick (19.7 in.), weighing 18 tons. Also the required tensile test was 56,890 to 78,220 lbs. per sq. in., with 18 per cent. elongation. The weight of the rough anchor with riser was 5 tons; the finished weight was 9,040 lbs.

The anchor was cast inclined in such a way that the end of the shank was about 4 in. below the horizontal. At this end there was an air pipe to remove the gases. The metal entered the casting through a large head or funnel 29½ in. long, 11⅝ in. high, and 19⅝ in. wide at the junction of the fluke and shank. When the funnel was two-thirds full and the whole mould completely filled, the steel in the funnel was covered with fine wood charcoal, and then slowly filled with steel. After a short time it was again filled with hot steel from the same ladle.

After loosening the casting to avoid the formation of cracks, it was allowed to stand for several days in the usual way, and then annealed in accordance with

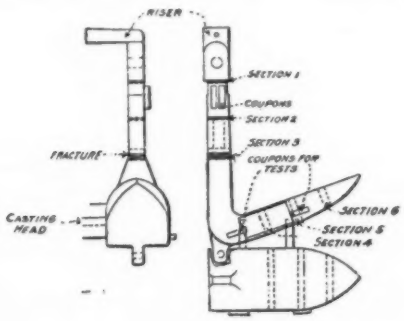

FIG. 1.

general practice. On cutting off the casting head no pipe or defect could be seen, and in general the casting showed no external flaw.

A section was cut from the broken anchor near the place of fracture, shown in Fig. 1 as section 3. One-fourth of this section was polished and etched, and showed very plainly a high carbon area near the centre. This is confirmed by the chemical results, which were:—

	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulphur, per cent.	Silicon, per cent.
Edge ..	0.16	0.70	0.035	0.050	0.41
Centre ..	0.40	0.65	0.040	0.052	0.37

This high-carbon area in the centre is obviously the cause of the failure, and, in order to investigate this further, sections were cut from the anchor at the places marked 1 to 6 in Fig. 1. The sections show that this high carbon area persists all through the anchor, but is least marked at the upper part of the shank where the microsections (Figs. 2 and 3) show the difference between edge and centre to be slight. At section 2 it is quite marked, and the results at section 3 have already been given. Further chemical results are given in the table.

In some way, therefore, after the primary crystallisation, the interior of still fluid steel has been raised in carbon.

The conclusions reached are that the failure of the anchor was caused by a hard interior, due to covering the fluid metal in the casting head with finely divided charcoal. Part of this was either carried along with

FIG. 2.

FIG. 3.

the liquid steel or else was dissolved in place. Such hard places are often found in large castings that are made with a feeding head, seen when the castings are machined and noticed by the difficulty in machining

Chemical Analyses of Various Sections of the Anchor.

Section.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulphur, per cent.	Silicon, per cent.
1. Edge ..	0.12	0.67	0.048	0.058	0.41
2. Edge ..	0.14	0.67	0.048	0.058	0.41
3. Centre .	0.44	0.67	0.052	0.061	0.41
4. Edge ..	0.11	0.67	0.034	0.038	0.47
Centre .	0.43	0.68	0.052	0.062	0.42
5. Edge ..	0.11	0.68	0.036	0.038	0.46
Centre .	0.44	0.68	0.054	0.062	0.42
6. Edge ..	0.11	0.65	0.036	0.042	0.45
Centre .	0.43	0.68	0.051	0.058	0.43

the place where the casting head is joined on. It is recommended that large massive castings, such as the fluke of the anchor, be made with several casting heads instead of one, and, further, that the charcoal used to cover the metal be as coarse as possible to still get good heat insulation. In many cases the use of slag or similar material is to be preferred.

TABOR COMPANY'S NEW PLANT.—The Tabor Manufacturing Company is now operating in its new plant at State Road and Devereaux Street, Wissinoming Station, Philadelphia, to which it began removal immediately after the fire, October 30, in its old plant at Hamilton and Eighteenth Streets. The fire, which necessitated the removal several months before the time contemplated, was unique, in that it inflicted such heavy damage on the building, a structure used for 50 years as a machine shop, yet spared to a great degree the manufacturing equipment which it contained. The company was fortunate, in that in September last it bought five acres on which stands the building into which it so hurriedly moved. A few years ago it purchased a site for a new plant at Nicetown, but the site was taken over by the United States Government. The new building is 100 × 350 ft., of steel and concrete construction, to which is being added an extension 100 × 108 ft. It has a saw-tooth type roof, cement floor, and, with a few modifications, will make an ideal plant for the company's purpose. It will contain spacious offices and much-needed room generally. It is served by the Pennsylvania Railroad, being on the main line between New York and Philadelphia. In the rear is a platform for loading both trucks and railroad cars. Less than one month elapsed between the fire and the resumption of full operations at the new plant.

Dowels.

By James Edgar.

The fitting of dowels is a very important part of a pattern-maker's work, and cannot be lightly considered as an unimportant detail. The usefulness of a pattern depends, frequently, upon the proper making of the dowels. If they are not a correct fit, the moulder, who excusably is annoyed, hacks at them with his pocket knife, or cuts them off altogether, with the result that unsightly fins of metal are left at joints. Further, it is possible that the desired thickness of metal is not obtained in the casting. Whereas the cabinet-maker inserts dowels as a cheap method of jointing two pieces of timber that have to be fastened permanently together, the pattern-maker's object is quite the opposite. Frequently a joint is not quite necessary, but simply advisable, and as screws cannot be relied upon for accuracy, and are also inconvenient, the method of dowelling is adopted, so that the pieces come freely apart and can be replaced accurately. It is well to press upon apprentices especially the objects of dowelling, and the importance of doing it the correct way. If dowels are loose they are worse than useless; if they are too tight they are dangerous, and cause the moulder no end of trouble.

Broadly speaking, there are five different kinds of dowels, or methods of dowelling, in use in pattern-making. These are socket-screw dowels, usually made of brass, plate dowels usually of iron, ordinary planed or turned dowel pins, square dowels sometimes used in core-box making, and spigot dowels. Usually two dowels are sufficient of whatever kind are used. It may be necessary when reliance is being placed on the dowels to keep two pieces of timber in line, to insert more than two dowels, or it may be convenient to use one or two dowels in several pieces, which have afterwards to be screwed together, but it is a safe general rule to use two. If more are used, apart altogether from the question of waste, there is a greater probability of them stiffening after the pattern has been in the damp sand a few times. This applies more especially, of course, in the case of large work.

It is strange how the old-fashioned turned or planed pin has retained its place in many pattern shops. This can be understood in the case of "one-off" jobs, or in special work, but not otherwise. They are very handy, however, for delicate ribs inside a core-box, or even for very small work. It is quite impossible to dowel a job satisfactorily with a blunt bit. Wooden dowels should be tightly driven, but the projecting or fitting part should be a very good fit, tapered practically all its length, and where the work is comparatively small, the dowel ought to go right through one half, so that they can be driven back to allow of the joint being planed. It is a mistake to use too small dowels in work, and especially in large work they cannot be too large. It can be readily seen that in handling a large pattern, small dowels soon get broken or worn, and in the joint plates of large patterns 1 in. or 1¼ in. wooden dowels are not too large, and they need not project more than ¾ in. It is foolish to have a long-fitting piece. A very wise precaution in patterns that are symmetrically designed is to fit two dowels of different sizes, so that the moulder cannot carelessly reverse the top half of the pattern.

For making dowels ash is hard, but it is tough. Baywood is not hard enough; teak is much better. Soft woods ought never to be used.

The objection to brass screw dowels is that they are too easily removed. Their very hardness in fitting is their disadvantage. Anyone who has used them knows how a slight mistake in boring causes a tightness, which can be remedied by a tap on the outside when the two halves are together. A similar tap in the foundry, and patterns are sometimes dropped there, would cause an inaccuracy. In well-seasoned hard wood, where both the dowels and the sockets are well-fitted, there is not as much danger, and, of course, they have the great advantage over wood that they stand a lot of usage before wearing. It takes some practice to fit brass socket dowels properly. If the sockets are loose they are useless, but if they are driven into too small a hole they may cause the pattern to split ultimately, even if it does not do so when being made.

All things considered, iron plate dowels are the best kind obtainable. There is no danger of splitting, and if the plates are not set much below the surface they fit just comfortably. They compare with wooden dowels in that they can be temporarily removed to plane joints. However, they cannot be used on very small work. The trouble with them is, that the special centres get broken or lost, but this, of course, is a matter for the shop foreman. The best job is undoubtedly obtained by planing the recess bored by the centre bit with a router, so that the plate lies on a level surface. There is practically no end to the life of iron plate dowels.

Where it can be done, as in the case of circular, built work, where, for example, there is a loose flange, or where the pattern must be jointed in two or more sections, a turned dowel neatly fitted makes a really fine job. Even if the pattern is made of pine the dowel should be of hard wood, and built if possible, as otherwise the dowel may become slack or tight across the grain, owing to shrinkage or swelling. A ½-in. dowel is sufficiently long. When this method of dowelling circular patterns or core-boxes is adopted, it makes a better finish to turn the actual faces of the work at the same time, that is, when all the joints have been made. To prevent one-half of the work from revolving on the other a small dowel may be fitted.

When making skeleton core-boxes it is much easier, and in other ways more satisfactory, instead of using ordinary round dowels, to screw battens on one half of the box, which will slip along side guide pieces on the other half. It is often possible to make the ordinary battens act as dowels in this way.

For very small work, really good dowels can be made from small screws. After the screw is turned in, the head can be sawn off. But this practice is only recommended where the dowel would be so small that if made of wood it would be too weak.

EXTINGUISHING OIL AND GAS FIRES.—The U.S. Bureau of Mines reports that during the past decade about 5,024,506,000 cub. ft. of natural gas and 12,850,000 barrels of oil have been destroyed by fires. Plans for handling such fires are discussed in a recent bulletin. At Coalinga, Cal., the Associated Pipe Line Company has installed two tanks holding an alkaline and an acid liquid which foam when mixed and produce bubbles of incombustible gas. Mixed in equal parts, one gallon of the mixture will produce 7 gallons of foam. The following foaming formulas are used, Solution A being mixed with Solution B, the proportions being parts by weight:—

Formula No. 1

Solution A:—Water, 100.00 parts; aluminium sulphate (crystal) 10.00 parts; sulphuric acid (66 deg. Baumé), 0.50 part.

Solution B:—Water, 100.00 parts; ground glue, .25 parts; glucose, 0.50 part; sodium bicarbonate 7.50 parts; arsenious oxide 0.02 part.

Formula No. 2.

Solution A:—Water, 100.00 parts; aluminium sulphate (crystal), 14.00 parts extract of licorice (powdered), 3.00 parts.

Solution B:—Water, 100 00 parts; sodium bicarbonate, 9.25 parts.

Formula No 3.

Solution A:—Water, 100.00 parts; aluminium sulphate (crysta's) 12.0 parts; acetic acid, 0.50 part; ground glue, 1.00 part; glucose 0.25 part.

Solution B:—Water 100.00 parts; sodium bicarbonate 10 00 parts; ground glue, 1.00 part; glucose 0.25 part.

These solutions can be stored in portable barrels for transportation to a fire or in stationary tanks with centrifugal pump delivering the frothing mixture through a pipe to the oil tank, burning pit or leak.

E

Trade Talk.

THE MILL CLOSE LEAD MINES, near Matlock, have been taken over by Mr. Chambers, of the Stanton Iron Works.

THE IRON & STEEL STOCKHOLDERS' ASSOCIATION have withdrawn from the British Federation of Iron, Steel, Tinplate, and Metal Merchants.

HERBERT MORRIS, LIMITED, of Loughborough, have acquired the business of Messrs. H. Coltman & Sons, Midland Ironworks, Loughborough.

BARIMAR, LIMITED, welding engineers, 10, Poland Street, W.1, have established a branch factory at 48, Rue d'Alsace, Clichy (Seine), France.

MESSRS. JESSOP & BOYDELL, of Bradford, are supplying five 800-k.v.a. single-phase furnaces to Tyssedal, Norway, for the smelting of Norwegian ore concentrates.

THE report of the judges on the farm tractor trials held last September at Lincoln, has now been published. Among tractors weighing less than 2 tons, the Austin tractor takes the first place.

CONSIDERABLE damage was caused by fire at the works of Messrs. Clifton & Waddell, machine tool makers, Laigh Cartside Street, Johnstone. The scene of the outbreak was a shed used as a pattern store.

THE BLAENAVON COMPANY, LIMITED, officially state that there is no truth in the rumours which have been circulated in regard to the amalgamation of this enterprise with other companies having similar interests.

In the Steel Company of Scotland's Hallside Works at Cambuslang an explosion took place on Monday, February 9, in a 40-ton furnace, whereby three men were seriously burned. Considerable damage was done to the furnace.

EDGAR ALLEN & COMPANY, LIMITED, Chicago, Ill., has been incorporated as an American company. Mr. J. C. Ward is the president, Mr. G. R. Bennett vice-president and general manager, and Mr. F. C. Leiferman secretary and treasurer.

We have received from Messrs. Thermit, Limited, Welding Engineers and Metallurgists, 675, Commercial Road, London, E.14, a useful pocket diary and calendar for 1920, in which they give a brief review of current "Thermit" practice.

THE syndicate which has been formed to establish a copper refinery in Devonshire has chosen a site near Newton Abbot. The chairman of the syndicate is Sir Gerard Muntz, who presided over the Non-Ferrous Metal Trades Committee, instituted by the Government during the war.

A PRIVATE limited company has been formed at Gloucester for the purpose of establishing a shipbuilding and ship repairing yard. The company have secured a site at the head of the Monk Meadow Docks, Mr. T. V. Ellis, for many years manager of Messrs. Finch's shipyard at Chepstow, being the prime mover in the project.

MESSRS. PETER LIND & COMPANY, engineers and reinforced concrete contractors, have removed from Parliament Mansions to more commodious premises at 2, Central Buildings, Westminster, S.W.1, in order to cope with the continually increasing demands upon their various departments. The telegraphic address and telephone number remain unaltered.

THE board of the Dominion Steel Corporation have appointed the following to be the London Advisory Committee:—Sir William Beardmore, Viscount Furness, General Sir Newton Moore, M.P., Colonel Grant Morden, M.P., Mr. Henry Steel, and Mr. Benjamin Talbot. Colonel Grant Morden has been elected chairman of the committee, and Viscount Furness vice-chairman.

THE Fanti Consolidated Mines, Limited, have not yet been successful in forming a company to develop their manganese property in the Gold Coast Colony, in consequence of not being able to secure from the Inland Revenue authorities an undertaking that the company will not be liable for income-tax on the shares received for their interest in the property. It was proposed to raise some portion of the capital in the United States.

THE moving photograph film of the Imperial Steel Works, Sheffield, of Edgar Allen & Company, Limited, has now been completed, and will be shown in many of the principal cities of this country. The film has been triplicated for three separate tours in various parts of the world. The first covers South America and Mexico; the second in South Africa, Australia, New Zealand, India, Egypt, and the Far East; and the third in Europe, Canada, and the States.

WE have received an interesting booklet describing their high-grade castings in non-ferrous metals from Messrs. Haywood Foundries, Limited, 30-31-32, Seaton Street, Euston Road, London, N.W.1. The specialities catalogued consist of aluminium alloys, brass, high-tensile bronze, gunmetal, phosphor bronze, and white-bearing metals. Full details, including mechanical test results and typical micro-photographs, are given. A most interesting feature of this booklet is the comparison between the mechanical test results of their high-tensile bronze and mild steel. The micro-photographs of these two alloys are also contrasted.

At Stand No. 9 of the Motorboat, Marine and Stationary Engine Exhibition, which will be held at Olympia from March 12 to 20, the Anglo-Mexican Petroleum Company (Kerosene and Spirit Department), 16, Finsbury Circus, E.C., will exhibit packages representing their well-known brand, Mex motor spirit (Grades No. 1 and No. 3) and "Empire" vapourising oil for tractors and other portable and stationary oil engines. Both these products are largely used in motor-boats, launches, barges and fishing boats. In addition, a range of samples representing "Snowflake," "Empire" and "Bearcreek" illuminating oils will be displayed.

THE report of the preliminary inquiry into the causes of the explosion from a vertical boiler at Chatts Colliery, Oakenshaw, near Bradford, has been issued. The observations of the engineer surveyor-in-chief to the Board of Trade are to the effect that the case illustrates the danger of relying on visual inspection and hydraulic testing, without taking the ordinary precaution to ascertain the thickness of the plates by drilling. Judging by the condition of the ruptured edge of the plate, it would appear that a hammer test would have indicated the advisability of drilling the plate to ascertain its actual thickness. It is, however, somewhat surprising that the firebox should have collapsed at a pressure of 45 lbs. per sq. in.

THE directors of Henry Bessemer & Company, Limited, find that, owing to the vastly increased and increasing cost of manufacture, additional working capital is necessary for the progress of the business. For instance, hematite pig-iron, which in 1914 was £3 12s. 6d. per ton, is now £11 15s.; coal, which was 13s. per ton, is now 31s. 6d. Wages have increased 230 per cent., and the company's turnover over 100 per cent. The directors propose that the capital be raised to £400,000 by the creation of 100,000 ordinary shares of £1 each, of which 50,000 shares should now be offered at a premium of 5s. per share to the holders of the existing ordinary shares in proportion, as nearly as may be, to their holdings, thereby providing £62,500 new money, and leaving 50,000 shares in reserve.

THE Trade Boards Acts, 1909 and 1918, are to apply to the waste materials reclamation trade, including:—(1) The collecting, sorting, or grading of scrap iron or other scrap metal, used tins, etc.; and (2) the following operations when carried on in association with or in conjunction with the collecting, sorting, or grading of the waste materials specified in (1) above:—The washing of used tins and the breaking of scrap metal; and (3) the operations of receiving, packing, compressing, craning, despatching, or warehousing when carried on in association with the above-mentioned operations; but excluding the above-mentioned operations when carried on in the establishment in

which the waste materials are produced, or in which they are used as raw materials for further manufacture.

THE STANTON IRONWORKS COMPANY, LIMITED, near Nottingham, have entered into an arrangement under which they purchase, as from January 1 last, the ironworks, foundries and ironstone properties of Messrs. James Oakes & Company, excluding, however, the collieries and clay works. The Stanton Company, with whom are incorporated the Holwell Iron Company, Limited, are the largest producers of pig-iron in the Midlands and of cast-iron pipes in Great Britain, and the purchase of the Oakes' business will add further three furnaces to the Stanton capacity, as well as give them control of a cast-iron foundry which is specially laid out for dealing with flange pipes and with iron castings of a general nature. In addition, the company have acquired the exclusive British and Colonial rights (Canada excepted) for the manufacture of iron pipes under the De Levaud centrifugal patent process, and are proceeding to put down an extensive plant at their Stanton works. It is claimed that by this new method it is possible to have a cast-iron pipe light in weight whilst of a strength approaching that of a steel pipe, and having a high resistance to corrosion. The quality of material permits of easy machining so that threaded joints may be used as well as the regular socket and spigot. It is expected that the pipe will compete in cost with the ordinary verti cally cast-iron pipe and with the commercial steel tube.

SIR EDWARD MACKAY EDGAR, of Messrs. Sperling & Company, Moorgate Street, recently announced that they had completed the purchase of the national shipbuilding yards at Chepstow in the interests of the following parties:—Lord Glanely, Mr. John Cory, Mr. E. Morel, Mr. T. H. Mordey, Mr. W. Leon, Mr. W. R. Smith, Sir W. Seager, the Fairfield Shipbuilding and Engineering Company, Limited, and the Anglo-Saxon Petroleum Company, Limited. Satisfactory arrangements are in progress for the supply of the necessary labour. It is the intention of the interested parties to enter into an extensive programme of shipbuilding and to develop the position at Chepstow as speedily as possible, which will involve considerable further expenditure. This purchase does not include the yard, etc., at Beachley, Portbury, and Portishead.

THE firms now or about to be associated under the Agricultural & General Engineers, Limited, include Aveling & Porter, Limited; Barford & Perkins, Limited; E. H. Bentall & Company, Limited; Blackstone & Company, Limited; Chas. Burrell & Sons, Limited; Clarke's Crank & Forge Company, Limited; Richard Garrett & Sons, Limited; James & Frederick Howard, Limited; and E. R. & F. Turner, Limited; and negotiations are now pending in respect to three other firms joining the combine. The central organisation offices will be established at Central House, Kingsway, on March 15, and these offices will be retained until the company's offices on the Aldwych site, which will be called "Alydwch House," are completed. The excavations for the foundation of this building will be commenced in the course of the next few days, and it is hoped to have the whole building completed within two years.

THE Admiralty have issued a statement at Pembroke Dock giving replies to several questions put by the Yard Committee regarding the proposed leasing of the Pembroke Yard to a private firm for merchant shipbuilding. The communication states:—That the firm is the Forth Shipbuilding Company, and that the date of transfer will be specified in the lease. The terms of the lease have not yet been determined, but the term would probably be for not less than 21 years. The Admiralty also state that any apprentice desiring to transfer would be allowed to do so, and that an undertaking from the new firm would be given that all apprentices who remained would be allowed to complete their apprenticeship with the firm. They further stated they would give an undertaking as to the minimum number of workpeople to be continued in employment, and this number would be the number at present employed, less the number transferred to other yards.

ERITH'S ENGINEERING COMPANY, LIMITED, 70, Gracechurch Street, London, E.C.3, are furnishing to the order of the Edinburgh Corporation, Erith-Riley stokers, which are much larger than any stokers hitherto made, each being no less than 33-ft. wide. The company are also furnishing identical stokers to the Shanghai Electricity Works, each stoker being assembled from standardised, uniform, self-cleaning retort-units, set side by side in a straight-walled furnace, under water-tube boilers normally evaporating no less than 80,000 lbs. high-pressure superheated steam hourly. The coal is fed, the fires are sliced, and the incombustible ash is continuously discharged without manual labour. The latest stokers for the Hull Corporation Electricity Works are exactly similar; but instead of being applied to one 80,000 lbs. boiler each, they are applied to a pair of 40,000 lbs. boilers, divided only by a partition wall, but allowing only half the capacity to be shut down at a time. In the case of the Charing Cross Electric Supply Company, the large boilers are set in pairs, but back to back.

THE shareholders in Guest, Keen & Nettlefolds, Limited, at a meeting held in Birmingham, adopted the resolution to increase the capital of the company in order to give effect to the agreement to purchase a controlling interest in the ordinary share capital of John Lysaght, Limited. There will be created 2,000,000 ordinary shares of £1 each and 3,000,000 second cumulative preference shares of £1 each, the latter to rank *pari passu* in all respects with the existing second cumulative preference shares of the company, and to rank for dividend as from January 1 last. The terms of the amalgamation are that four second preference shares of £1 each and three ordinary shares of £1 each in Guest, Keen & Nettlefolds, credited as fully paid, shall be allotted to the holders of ordinary shares in John Lysaght, Limited, in exchange for every three ordinary shares of £1 each in that company held by them. The Earl of Bessborough, who presided, said the amalgamation was a unity for greater strength, and in such combinations would be found the most effective means for holding Britain's position in the world's markets against the fierce competition that was ahead. Those two vast enterprises had community of interests, and the combination of their knowledge, experience and productive power could not fail to be highly advantageous to the shareholders.

IN regard to the increased demurrage charges, Mr. W. Simons, chairman of the Transport Committee of the National Federation of Iron and Steel Manufacturers, and the Director of the Federation, Mr. W. T. Layton, have addressed an interesting letter to the Press pointing out the unfairness of levying a charge of the kind proposed without due discrimination. The correspondents point out that so far as the iron and steel industry is concerned, while manufacturers recognise the importance of minimising the detention of railway wagons and generally have spared no effort to meet the national interests and the conditions resulting from so many wagons having been transferred to France, with the best will in the world no works handling hundreds of tons of railborne material per day is able to deal with this traffic unless it moves in and out with some degree of regularity. The committee point out that great efforts have been made by manufacturers at considerable increase of cost to deal with incoming and outgoing wagons. It is pointed out that the railway companies frankly admit their inability to handle traffic regularly in present circumstances, and that recent railway history has been a continuous succession of "areas closed to traffic owing to congestion." As an example of the apparent inability of the railway companies to clear wagons at the present time the following figures are given:—Wagons refused by railway company—loaded and empty—owing to

their not being able to accept: From November 5 to 29, inclusive, 1,641; from December 1 to 17 inclusive, 3,539.

At the request of the National Council of the Commercial Motor Users' Association, the Petroleum Executive and the Aeronautical Inspection Department last year undertook to make investigations as to the effect of sulphur in benzole on various metals. The specification of the National Benzole Association fixes 0.4 per cent. of sulphur as the maximum. The association has received the results of this investigation, concerning specially procured benzole with an excessive sulphur content, and the permission of Sir John Cadman to publish the report as follows:—Four samples of benzole were supplied, stated to contain 0.1, 0.2, 0.4, and 0.8 per cent. sulphurs respectively. Chemical examination of these showed that the sulphur was nearly all present as carbon bisulphide. The metals used were copper, brass, phosphor bronze, aluminium and cast-iron. After prolonged contact with benzole containing 0.8 per cent. combined sulphur, a slight discolouration of the surface was obtained with copper and brass. In the presence of moist air, also, slight action appears to take place, but no measurable difference occurred in the weights of the metals before and after the action. The iron and steel rusted in the moist air, but there was no evidence of the formation of any oxidation products of sulphur. In view of these results, as no corrosion occurred, the answer to the questions as to whether corrosion had in any case reached the degree of perforation of a sheet of metal is in the negative. A sample of the deposit found in carburettors or aero engines was found to consist of a greyish-white powder decidedly alkaline to litmus, and containing metallic particles. The metallic particles consisted of aluminium with traces of zinc, copper, and iron. The remainder of the deposit was sodium silicate with traces of carbonate and sulphide, the latter being probably impurities present in the sodium silicate used for "doping" the carburettors. There is, therefore, no evidence that the sulphur in benzole (there is no free sulphur) has any corrosive effect on carburettors.

A short description of the foundry built by the British Government during the war at Brentford was presented at the annual convention of the American Foundrymen's Association, Philadelphia, by Mr. G. Ernest Wells, of Messrs. Edgar Allen & Company, Sheffield. Primarily, the purpose was to make researches into all questions affecting malleable castings. Before the war, makers of pig-iron specialised in brands suitable for use in the manufacture of malleable iron castings. Each foundry made tests of the different brands and eventually bought those particular ones which best suited its methods. After the outbreak of the war, malleable iron founders still continued to buy the brands of iron which had given them satisfaction in the past, but found all sorts of new troubles cropping up for no apparent reason. Had all the foundries been in possession of up-to-date chemical laboratories they would have quickly discovered that the analysis of their material had completely changed. The plant at Brentford contained an up-to-date cupola, a number of pot-holes, one or two different types of annealing furnaces, and a completely equipped physical and mechanical testing laboratory. This laboratory was put in charge of a skilled research chemist who had specialised in malleable-iron problems, while the foundry itself was in charge of a malleable-iron founder of considerable experience. As the work developed, difficulties of all sorts experienced by manufacturers were put up to the Government's experimental foundry for solution, and after a thorough investigation a report was made which was at the disposal of any founder who wished to see it. In this way a great deal of valuable work was done, and in certain cases raw materials were successfully used which hitherto had been considered unsuitable for the manufacture of malleable castings. At a later date, a good deal of help was given to firms who were experiencing difficulty in the manufacture of semi-steel shell, and demonstrations were arranged at Brentford so that contractors were able to send their technical men to see exactly how success was to be attained.

A representative deputation of steel makers, engineers, shipbuilders, etc., in the North-east Coast area waited upon the directors of the North-Eastern Railway Company on Thursday, February 5, on the subject of wagon shortage. Lord Knaresborough, chairman of the company, presided. Attention was drawn by the deputation to the serious disorganisation of the shipbuilders' programmes, due to the inadequate supply of material. The effect of the shortage of supplies had resulted in a restriction of output, was causing unemployment, and creating dissatisfaction and unrest amongst the men. Instances were given of abnormal delays in the transit of finished steel from the steel works to the shipyards and engineering establishments. Lord Knaresborough, in reply, stated that on the Board of Directors there were a good many gentlemen interested in this question. They had been trying their best to alleviate the situation. He pointed out that the question of wagons had always been with them, and explained the difficulties they had in providing siding accommodation to stock empty wagons when not in use. They had had a scheme under consideration just before the war which would have resulted in a sufficient supply of wagons being forthcoming, but the war had operated against their being able to carry out the programme. While shipyards and engine works had during the war extended their operations, it had not been possible for the railway companies to go ahead and keep their system of service equal to the increased requirements. They were very much alive to the position, and the question of cost did not enter into their consideration. They had ordered to the extent of 7,000 wagons since the Armistice from outside firms, in addition to the building programme they had in hand themselves, but, so far, only a few hundred of the additional wagons had been supplied. They were centreing their attention at the moment on the supply of bolster wagons, which were specially required for the steel trade, and they hoped at an early date to increase the number of that type of wagon.

Deaths.

The death occurred with unexpected suddenness, at his residence, Consett Hall, on January 18, in his 70th year, of Mr. George Ainsworth, late general manager of the Consett Iron Company, Limited. The deceased gentleman was a son of Mr. George Ainsworth, of Macclesfield. He commenced his business career with the North Staffordshire Railway Company, and later went to the Dowlais Iron Company, then under the management of the late Mr. G. J. Snelus. Mr. Ainsworth left there to take up the position of chemist to the West Cumberland Iron Company, and in 1870 he entered the service of the Consett Iron Company, Limited, as chemist. Later he was appointed blast-furnace manager, and subsequently combined the management of the steel works plant. On the retirement of the late Mr. W. Jenkins, Mr. Ainsworth was appointed general works manager, and some few years later he was made general manager of the company, a position he held until his retirement in March, 1919. For many years he was president of the Steel Ingot Makers' Association, as well as occupying a prominent position on the various employers' associations connected with the coal, coke, and iron and steel trades. In addition, Mr. Ainsworth was managing director of the Orconera Iron Ore Company, Limited, a director of the Northumberland & Durham Colliery Owners' Mutual Protection Association, a director of the Olga Iron Ore Company, Limited, and a director of the French Iron Ore Company, Limited. Mr. Ainsworth was also a vice-president of the Iron & Steel Institute, and a member of the Council of Armstrong College, Newcastle.

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Type "A" Duplex Machine for Pneumatic Power.

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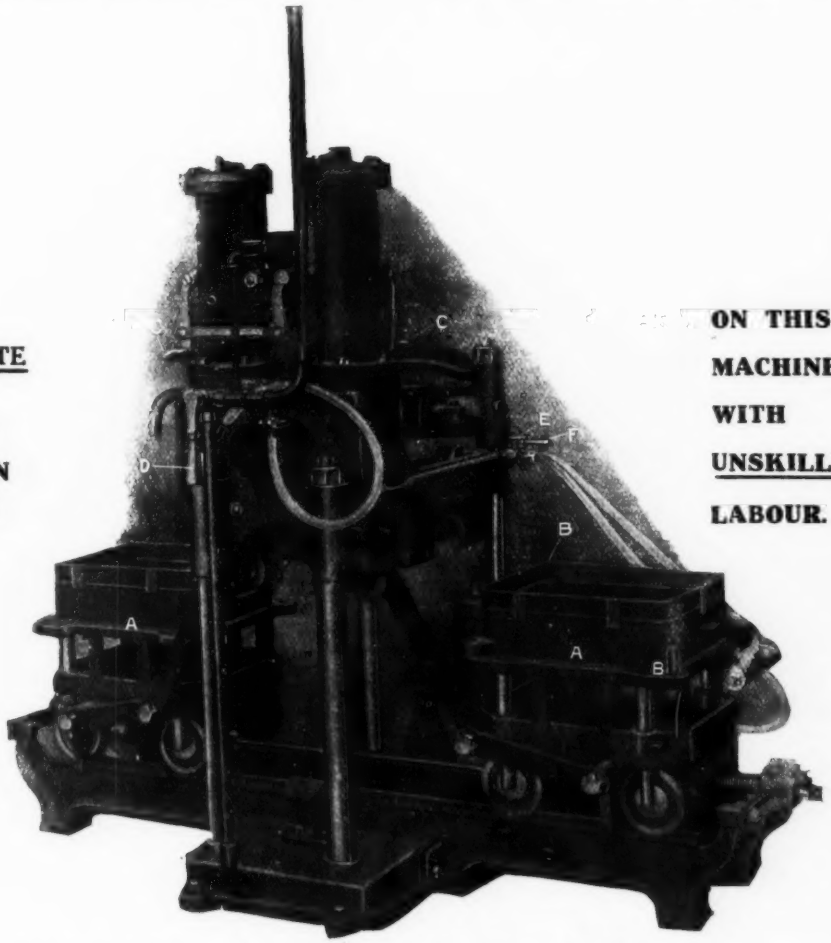

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Personal.

MR. F. MERRICKS has been elected president of the Institution of Mining and Metallurgy.

THE late Mr. S. T. Meynell, iron manufacturer, Newcastle-on-Tyne, left estate valued at £18,082 8s., with net personalty £16,509 6s.

THE late Mr. R. B. Stoker, M.P., a director of the Tyne Dock Engineering Company, Limited, left estate valued at £235,054, with net personalty £171,531.

MR. J. ROSE has been elected a director of the Penarth Pontoon, Slipway, and Ship Repairing Company, Limited, in place of Mr. W. J. Tillett, resigned.

THE COUNCIL OF LIVERPOOL UNIVERSITY have appointed Mr. G. E. Scholes to the recently-established Chair of Engineering—Thermodynamics of Heat Engines.

MR. H. J. SKELTON has been elected chairman of the Iron, Steel, Tinplate, and Metal Merchants' Section of the London Chamber of Commerce, with Mr. P. Donald as deputy-chairman.

SIR ARCHIBALD DENNY has been re-elected Master of the Worshipful Company of Shipwrights, with Mr. A. J. Fells, J.P., Brigadier-General H. H. J. W. Drummond, Sir Charles A. Parsons and Sir Charles Edward Ellis as Wardens.

MR. J. BAGGOTT, the chief engineer of Arthur Lee & Sons, Limited, Crown Steel and Wire Mills, Sheffield, has been the recipient of presentations from the directors, officials, and men on the occasion of his leaving Sheffield to take up a position in Leeds.

CHANGES in management at Messrs. Vickers' shipyard at Barrow have been announced. Mr. Alexander Smith, who for some years has been the shipyard works manager, has received a similar appointment with Messrs. Denny & Brothers, Dumbarton, and Mr. J. Ford has been appointed in his place as manager at the Barrow yard. Mr. Ford for some time was chief of Messrs. Vickers' foreign office.

MR. F. DUDLEY DOCKER, chairman of the Metropolitan Carriage, Wagon & Finance Company, Limited, has been the recipient of a presentation from the shareholders of the company in appreciation of the energy and ability with which he has administered the affairs of the company during the past seventeen years. The presentation was accompanied by a sum of money for the creation of scholarships at the Birmingham University bearing Mr. Docker's name.

THE Lord President of the Council has approved the appointment of Colonel Sir Frederic Nathan, to be Power Alcohol Investigation Officer under the Fuel Research Board of the Department of Scientific and Industrial Research. Sir Frederic Nathan, who before the war was superintendent of the Royal Gunpowder Factory at Waltham Abbey, and later works manager of Messrs. Nobel's explosives factory, Ardeer, was the officer in control of alcohol under the Ministry of Munitions during the war, and chairman of the Production Section of the Inter-departmental Committee. Professor Pierce Purcell, who was secretary of the Irish Peat Inquiry Committee, has also been appointed to act as Peat Investigation Officer under the Fuel Research Board.

ORIGIN OF ORE DEPOSITS. — Mr. E. C. Harder, of the United States Geological Survey, who has examined iron ore deposits in many countries for the special purposes of finding out their mode of origin, has recently made close studies of the action of bacteria. He has found the so-called "iron bacteria" actively engaged in the deposition of compounds of iron, not only in surface iron-bearing waters, but in mine waters to depths of several hundred feet, and has made laboratory cultures of various iron-depositing bacteria. The results of these studies have just been published by the Survey as a Paper entitled "Iron-Depositing Bacteria and Their Geologic Relations."

Applications for Patents.

Auliff, M., and Douglas, R. Process for manufacture of tubes and hollow metal goods. 3,017. January 31.

Bairstow, W. Tubular or hollow drills for drilling or boring holes into metal. 2,033. January 22.

Ballantine, W. B. Production of metallic alloys. 1,137. January 13.

Bass, J., and Musto, W. J. Tool-holders for lathes, etc. 1,925. January 21.

Claremont. E. A., and Stratton, J. Machines for extruding lead, etc. 1,214. January 14.

Cobley, W. D. Metal stanchions. 2,280. January 24.

Coles, S. O. Cowper-. Process of coating steel and iron with brass. 1,142. January 13.

Coles, S. O. Cowper-. Process for building up undersized parts of machinery. 1,144. January 13.

Dunn, W. Mechanical appliance for turning crank-pins in outside discs, cranks, or wheels in their places. 2,749. January 29.

Durant. H. C., and Vautin, C. Smelting of zinc. 2,340. January 24.

Fletcher, R. J. Electro-deposition of metals on iron and alloys of iron. 2,710. January 28.

Gilbertson & Company, W. Stoppers or valves for foundry ladles, etc. 1,530. January 17.

Harper, H. Means for grinding reamers, boring bits, etc., in lathes, etc. 2,886. January 30.

Herbert, Sir A. Self-opening die-heads for turret lathes, etc. 2,074. January 22.

Hosack, H. H. Casting steel, etc. 1,300. January 15.

Honhorst, W.C. Steel alloys, and process of making same. 1,829. January 20. (United States, December 8, 1917.)

Hugill, A. G. Crucible furnace. 2,191. January 23.

International Nickel Company. Manufacture of nickel and copper. 1,013. January 12. (United States, February 5, 1919.)

Jones, E. H. Repair and reinforcement of iron and steel castings. 2,933. January 30.

Kennelly, J. W. Chucks for capstan lathes, etc. 1,735. January 20.

Kuhn, P. Regenerators for smelting-furnaces, etc. 1,845. January 20. (Germany, May 4, 1918.)

Lindemuth, L. B. Sink heads, feeders, or hot-tops for casting ingots, etc. 2,577. January 27.

Lister, W. Stoppers or valves for foundry ladles, etc. 1,530. January 17.

Massey, B. & S., and Snow, W. H. Drop stamps, etc. 1,548. January 17.

Pankhurst, V. H. Hayes-. Screw-thread cutting-devices. 2,362. January 26.

Reads, Limited. Sealing-plugs of sheet-metal receptacles. 2,519. January 27.

Renault, L. Sheet-metal wheels. 2,449. January 26. (France, October 21, 1919.)

Runbäck, K. G. M. Machine for bending metal bars, etc. 949. January 12. (Sweden, January 11, 1919.)

Skinningrove Iron Company. Drying washed mineral matter. 2,180. January 23.

Smith. D. Couplings for rods, tubes, etc. 2,278. January 24.

Village, R. Hot feeder head for steel ingots. 3,079. January 31.

Wardle, G. W. Metal moulds or dies for production of castings. 2,187. January 23.

Wigram, A. W. Apparatus for projecting sand, etc., for moulding for foundry purposes, plastering, rough cast work, and concrete construction. 986. January 12.

Wilson, H. Tap and die holders for capstan or turret lathes, etc. 2,873. January 30.

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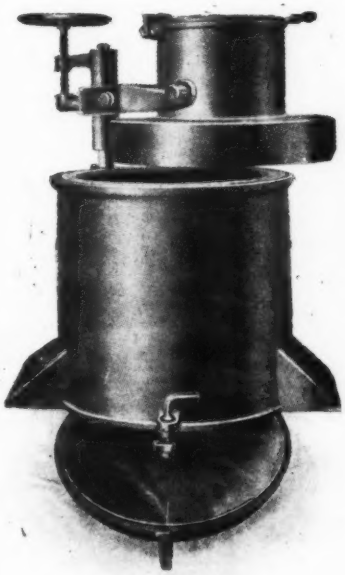

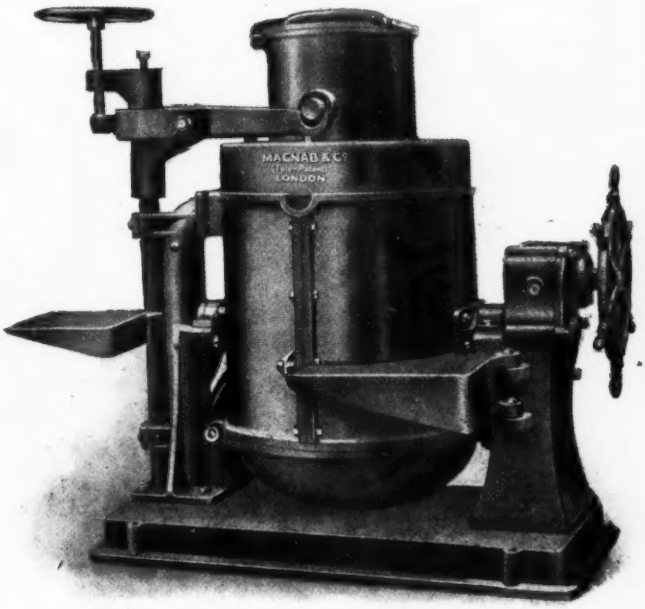

Tylor Patent Pit-Type Furnace.

OUTPUT.
200 lbs. Admiralty Gunmetal melted in 35 minutes. Temperature 2000° F.=1093° C.

ECONOMY.
25 lbs. of Coke used per 200 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.

Tylor Patent Tilting-Type Furnace.

OUTPUT.
400 lbs. Admiralty Gunmetal melted in 50 minutes. Temperature 2000° F.=1093° C.

ECONOMY.
80 lbs. of Coke used per 450 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 30 to 40 heats.

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New Companies.

Stoves, Limited.—Capital £20,000 in £1 shares.

Edge Tools, Limited.—Capital £100 in £1 shares.

Power Research Company, Limited.—Capital £100,000 in £1 shares.

Leyland Construction Company, Limited.—Capital £25,000 in £1 shares.

Faracatu Hematite Company, Limited.—Capital £120,000 in 10s. shares.

Castle Engineering Company, Limited.—Capital £5,000 in £1 shares (2,500 preference).

Baico Patents, Limited. — Capital £25,000 in £1 shares, to carry on the business of engineers.

Castle Engineering Company, Limited. — Capital £5,000 in £1 shares (2,500 preference).

British Generator Company, Limited.—Capital £5,000 in £1 shares. Registered office: 481, Oxford Road, Reading.

General Welding Company, Limited.—Capital £10,000 in £1 shares. Registered office: 19, Muirhouse Street, Glasgow.

Waltham Engineering Company, Limited.—Capital £25,000 in £1 shares. Registered office: 5, Victoria Street, S.W.

Newent Engineering Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc.

Hub Ironworks Company, Limited.—Capital £5,000 in £1 shares. Registered office: 7, High Street, Chipping Norton.

Nigerian Base Metals Corporation, Limited.—Capital £100 in £1 shares. Registered office: Finsbury Pavement House, E.C.

Bernard Tomlinson, Limited.—Capital £3,000 in £1 shares, to acquire the business of heating engineers at Argyle Street, Glasgow.

Continental Metal & Minerals Company, Limited.—Capital £100,000 in £1 shares. Registered office: 30-31, St. Swithin's Lane, E.C.

A. G. Wild & Company, Limited.—Capital £55,000 in £1 shares (5,000 deferred), to carry on the business of rolling stock manufacturers.

Wright's Metal Company, Limited.—Capital £20,000 in £1 shares. Registered office: Reliance Works, Liverpool Street, Birmingham.

Curtis Foundry and Engineering Company, Limited.—Capital £20,000 in £1 shares. Registered office:—Camel Road, Silvertown, E.16.

Evans' Concinnum & Metal Works, Limited.—Capital £5,000 in £1 shares. Registered office: Blackfriar's House, New Bridge Street, E.C.

American Chemical and Metallurgical Corporation, Limited.—Capital £40,000 in £1 shares. Registered office: 441, Salisbury House, E.C.

Hack Engineering Company, Limited. — Capital £10,000 in £1 shares (2,000 deferred). Registered office:—44, Victoria Road, Hendon.

Ramsdell Engineering Company, Limited. — Capital £5,000 in £1 shares. Registered office: Kent Green Works, Scholar Green, Stoke-on-Trent.

Warrenpoint Shipbuilding and Engineering Company, Limited.—Capital £100,000 in £1 shares. Registered Office: 49, St. James Street, S.W.

Barrett & Wright, Limited.—Capital £13,000 in £1 shares, to carry on the business of engineers. Registered office: 19, Bartholomew Close, E.C.

Andrew Baxter, Limited.—Capital £20,000 in £1 shares, to carry on the business of iron and steel manufacturers, etc. Registered office: Coatbridge.

Thompsons & Culshaw, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers. Registered office:—79a, Linaker Street, Southport.

Black & Malloch, Limited.—Capital £2,000 in £1 shares, to carry on the business of engineers.—Registered office:—62, Cathcart Road, Rutherglen.

Marine Engineering Company (Port Talbot), Limited.—Capital £10,000 in £1 shares. Registered Office: Gloucester House, Gloucester Place, Swansea.

Sykes & Sugden, Limited.—Capital £75,000 in £1 shares, to carry on the business of engineers. Registered office: George Street, Huddersfield, Yorks.

W. H. Taylor & Company, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers. Registered office: 29, Fountain Street, Manchester.

Testar & Swain, Limited. — Capital £10,000 in £1 shares, to carry on business as metal manufacturers. Registered office: 95, Pritchett Street, Birmingham.

Hybart, Broadhead & Company, Limited.—Capital £25,000 in £1 shares, to carry on the business of engineers. Registered office: 6, Suffolk Street, S.W.

Brooks & Adams, Limited.—Capital £30,000 in £1 shares, to carry on the business of brassfounders. Registered offices: 250-252, Barr Street, Birmingham.

Shotton Brothers, Limited.—Capital £25,000 in £1 shares, to carry on the business of metal manufacturers. Registered office: Manchester Street Foundry, Oldbury.

Donald McCall & Company, Limited. — Capital £15,000 in £1 shares, to carry on the business of iron merchants. Registered offices: 27, Greenwich Road, S.E.

Palmer Foundry Company, Limited.—Capital £25,000 (20,000 £1 preferred, and 20,000 5s. ordinary). Registered office:—Albion Works, North Street, Clapham, S.W.4.

Rimmer & Brear, Limited.—Capital £1,000 in £1 shares, to carry on business as ironfounders, etc. Registered office: 51a, Broughton Road, Pendleton, Manchester.

I. Calvete, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers. Registered office:—11, Little Street, Andrew Street, St. Martin's Lane, W.C.

H. A. Jones & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of hardware manufacturers. Registered office: 12, Cherry Street, Birmingham.

James Evans & Company (London), Limited.—Capital £15,000 in £1 shares, to carry on the business of engineers. Registered offices: 10, Bush Lane, Cannon Street, E.C.

Allen & Simmonds (Reading), Limited. — Capital £350,000 in £1 shares, to acquire the existing engineering company. Registered office: 42, De Montford Road, Reading.

H. Ronnebeck & Company, Limited.—Capital £50,000 in £1 shares, to carry on the business of iron merchants. Registered office: Zetland Buildings, Marton Road, Middlesbrough.

Wolsey Engineering Company, Limited.—Capital £5,000 in 4,500 ordinary of £1 and 10,000 deferred of 1s. Registered office: Old Post Office Chambers, King Street, Ipswich.

Bristol Vulcan Engineering Company, Limited.—Capital £10,000 in 9,750 ordinary of £1, and 5,000 deferred of 1s. Registered office: 55a, Church Road, Redfield, Bristol.

Skellingtons, Limited.—Capital £50,000 in £1 shares (20,000 preferred), to carry on the business of iron manufacturers. Registered office: 144, Princess Street, Attercliffe, Sheffield.

Edwin Ellis & Company, Limited.—Capital £50,000 in £1 shares (20,000 preference), to carry on the business of wire rope manufacturers. Registered office: Alpha Road, Millwall, E.

Albany Forge, Wainwright, & Waring, Limited.—Capital £8,000 in £1 shares, to carry on the business of engineers. Registered office:—45, Goldhawk Road, Shepherd's Bush, W

Auto Consulting & Engineering Company, Limited.—Capital £5,000 (3,500 £1 preference and 30,000 1s. ordinary). Registered office: Ulster Chambers, 168, Regent Street, W.1.

Hulbert D. Carter (Bangor), Limited. — Capital £5,000 in £1 shares (3,000 preference), to carry on the business of engineers. Registered office: Faraday House, 249, High Street, Bangor.

A. G. Wild & Company, Limited.—Capital £55,000 in £1 shares, to carry on the business of manufacturers of

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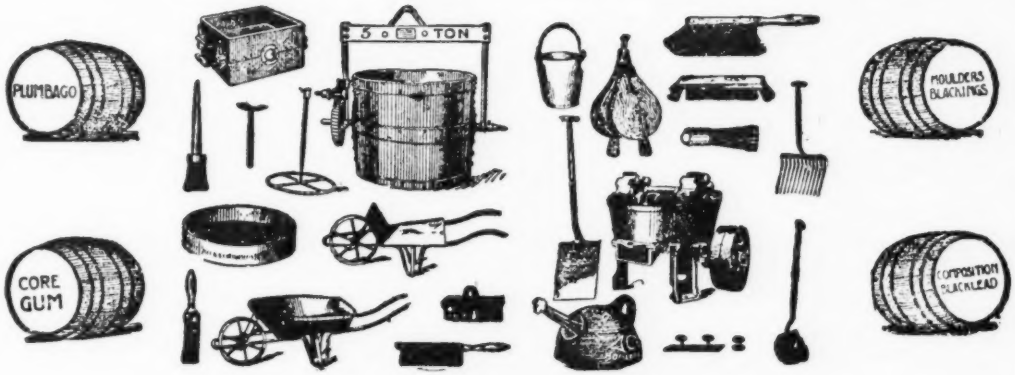

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FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

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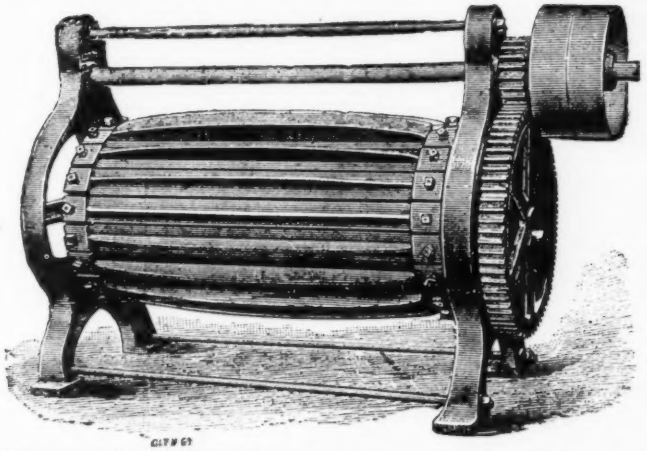

These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

and dealers in railway and other rolling stock, etc. Directors: A. G. Wild and J. W. Spencer.

Charles Leek & Sons, Limited.—Capital £20,000 in £1 shares (8,000 preference), to take over the business of engineers, etc., carried on at the Britannia Works, West Street, Leek, as Charles Leek & Sons.

Everitt & Company, Limited.—Capital £100,000 in £1 shares (25,000 10 per cent. cumulative preference), to carry on the business of metal merchants, etc. Registered office: 40, Chapel Street, Liverpool.

Hook & Willis, Limited.—Capital £10,000 in £1 shares (5,000 7½ per cent. non-cumulative preference), to carry on the business of hardware manufacturers. Registered office: 3, Denman Street, London Bridge, S.E.

Gibby's, Limited.—Capital £4,000 in £50 shares, to carry on the business of engineers, etc. First directors: G. R. Gibby, W. Beasley, T. Williams, and R. L. Geasley. Registered office: Riverside, Neath.

Auto-Products, Limited.—Capital £10,000 in £1 shares (5,000 cumulative preference), to carry on the business of engineers. Registered office: Back Thornleigh Road, West Jesmond, Newcastle-on-Tyne.

J. B. Addis & Sons, Limited.—Capital £3,000 in £1 shares, to take over the business of tool manufacturers, carried on by Mrs. E. Addiss as J. B. Addis & Sons, at Arctic Works, St. Thomas Street, Sheffield.

Ordsall Wire Mills, Limited.—Capital £120,000 in £1 shares. First directors: E. Smith, A. Smith, Harry Smith, Herbert Smith, F. Smith, and E. Smith, jun. Registered office: Ordsall Wire Mills, Ordsall, Retford.

Gadgets, Limited.—Capital £2,000 in £1 shares, to carry on the business of manufacturers of motor and aeroplane parts and accessories, etc. Registered office: 34, International Exchange, Edmund Street, Birmingham.

W. H. Syndicate, Limited.—Capital £22,000 in 20,000 ordinary of £1 and 40,000 deferred of 1s., to carry on the business of engine and chassis manufacturers. Registered office: 41, Regent House, Regent Street, S.W.

James B. Tait & Company, Limited.—Capital £10,000 in £1 shares, to carry on business at Middlesbrough as consulting engineers. Directors: D. L. Cooper and J. B. Tait. Registered office: 24, Albert Road, Middlesbrough.

E. H. Druce & Company, Limited.—Capital £5,000 in £1 shares, to take over the business carried on at Coventry as E. H. Druce & Company, and the Coventry Packing Case Company, and to carry on the business of metal founders, etc.

Rudge Foundry & Engineering Company, Limited.—Capital £10,000 in £1 shares, to take over the business carried on at Church Lane, West Bromwich, as the Rudge Foundry Company, and to adopt an agreement with J. J. D. Rudge.

Ellis Brothers, Bigham & Morris, Limited.—Capital £7,000 in £1 shares, to carry on the business of puddlers, forgers, etc. First directors: T. V. Ellis, A. B. Ellis, C. J. Ellis, J. W. Bigham, and J. S. Morris. Registered office: Monk Meadow Dock, Gloucester.

J. Thomas Edwards & Sons, Limited. — Capital £10,000 in £1 shares (5,000 preference), to take over the business of a brassfounder, etc., carried on by J. T. Edwards as T. Edwards & Sons, at Stratford House (St. Martin's and St. Peter's Place), Broad Street, Birmingham.

S. & G. A. Allwood, Limited.—Capital £15,000 in £1 shares, to carry on the business of engineers and ironfounders as formerly carried on by S. Allwood and G. A. Allwood, senr., as S. & G. A. Allwood, at the Derwent Foundry, Milford, near Derby. First directors: S. Allwood (permanent), G. A. Allwood, senr., G. B. Allwood and G. A. Allwood, junr. Registered office: Derwent Foundry, Milford, Derby.

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DIE-CAST IT.

Magneto Parts, Ball Bearing Parts, Die-Cast with Steel Balls in complete. Bearings, Screw Threads, Gears, Accumulators, Grids, Wheels, Rings, etc., etc.

The only heat controlled die-casting plant on the world's market.

Pressure of 7 tons obtained.

Complete castings up to 40-lbs. white-metal alloys can be made in one operation.

Interchangeable nozzles for different sizes of castings.

Interchangeable pots.

For the production of "dead-size die castings" in tin, lead, zinc and aluminium alloys and all white metals.

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MONOMETER MANUFACTURING Co.

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COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

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Our Specialite is Studying Special Requirements.

KINDLY HAND US YOUR ENQUIRIES.

The Mastery

of the Air.

FANS

SEND US YOUR ENQUIRIES FOR

are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

Davidson & Co., Limited, *Sirocco Works,* **BELFAST.**

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

	Home £ s. d.
Hematite—	
East Coast Mixed Nos.	11 0 0
East Coast No. 1	11 2 6
West Coast Mixed Nos.	12 5 0
Scottish Mixed Nos.	11 10 0
Welsh Mixed Nos.	12 10 0
Cleveland—	
No. 1	9 2 6
No. 3 foundry G.M.B.	8 15 0
No. 4 foundry	8 15 0
No. 4 forge	8 15 0
Basic	9 5 0
Derbyshire, Leices., and Notts—	
No. 4 forge	9 15 0
No. 3 foundry	10 0 0
No. 2 foundry	10 2 0
No. 1 foundry	10 4 0
Basic	10 2 6
Northamptonshire—	
No. 4 forge	9 10 0
No. 4 foundry	9 11 6
No. 3 foundry	9 12 6
No. 2 foundry	9 13 6
No. 1 foundry	9 15 6
Basic	10 2 6
South Staffordshire, Shropshire and Worcestershire—	
Part-mine forge	10 5 0
Part-mine foundry	10 7 6
Common Staffs.	9 5 0
All-mine forge	10 17 6
All-mine foundry	11 2 6
Warm-air forge	11 17 6
Warm-air foundry	12 7 6
Cold blast	15 15 0
Basic	10 0 0
Scottish—	
Foundry	11 0 0
Delivered in Manchester—	
*Derbyshire, No. 3	—
*Cleveland, No. 3	—
*Scottish, No. 3	—
* Merchant prices.	
Delivered in Sheffield—	
East Coast hematite	—
Derbyshire basic	—
Lincolnshire basic	—
Do. No. 3 foundry	—
Do. forge	—

High-Speed Tool Steel.

	s. d.
Finished bars, 14 per cent. Tungsten	3 2
Finished bars, 18 per cent. Tungsten	3 9
Per lb. delivered buyers' works.	
Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. per lb.
Rounds and squares under ½ in. to ¼ in.	3d. ,,
Flats under 1 in. by ¾ in. to ½ in. by ½ in., and all sizes over four times 3 in width and over thickness	3d. ,,
Bevels of approved sizes and sections	6d. ,,
If in Coils	3d. ,,
Packing	4s. per cwt
Bars cut to length	10% extra
Scrap from High-Speed Tool Steel—	
Scrap pieces, 5d.	
Turnings and Swarf, 3d.	
Per lb. net, d/d steel-makers' works.	

Ferro-Alloys.

Ferro-Titanium—23/25% Ti. carbonless, 1/6.
Ferro-Tungsten.—75/80%, 2/9.
Ferro-Molybdenum.—70/80%, Mo., 8/9.
Ferro-Vanadium.—35/40%, Va., 53/-.
Metallic-Manganese,—98/99% carbonless, 3/-.
All per lb.).
Ferro-Phosphorus—20/25%, P. £—
Ferro-Chrome.—4/6%, car., £42 10 0.
Ferro-Chrome.—6/8%, car., £42 10 0.
Ferro-Chrome.—8/10%, car., £42 10 0.
Ferro-Chrome —Specially refined, basis 60% chr., max. 2% car., £99 0 0.
Ferro-Silicon.—45/50% Si., £22 0 0 d/d. at Sheffield Steelworks.
Ferro-Manganese.—80%, £30 loose, £31 packed. Export £32 10s., according to destination.
(All per ton.)

Copper.

	£ s. d.	£ s. d.
Standard cash	121 0 0	121 5 0
Three months	123 12 6	123 15 0
Electrolytic	128 0 0	131 0 0
Tough	126 0 0	127 0 0
Best selected	127 0 0	128 0 0
Sheets	173 0 0	—
India	172 0 0	173 0 0
American electrolytic spot	128 10 0	—
Do. April	129 0 0	129 10 0
Official average price cash, Jan.		118 4 1½
Do. Three months, Jan.		120 7 8½
Do. Settlement, Jan.		118 4 9½
Do. Electro, Jan.		123 18 9½
Do. B.S., Jan.		123 5 6½
Average spot price, copper, Jan.		118 2 1¼
Do. Electro, Jan.		123 4 9

Tin.

	£ s. d.	£ s. d.
Cash	415 10 0	416 0 0
Three months	418 0 0	418 10 0
English	410 0 0	412 0 0
Bars	412 0 0	414 0 0
Refined	—	—
Straits	415 10 0	416 0 0
Australian		415 10 0
Eastern		407 10 0
Banca		415 10 0
Official average price, cash, Jan.		376 12 8½
Do. Three months, Jan.		378 0 10
Do. Settlement, Jan.		376 11 5½
Average spot price, Jan.		376 10 5¼

Spelter.

	£ s. d.	£ s. d.
Ordinary	61 10 0	—
Remelted	57 0 0	59 0 0
Hard	49 0 0	51 0 0
Electro 99.9	67 0 0	—
English	65 0 0	—
India	56 0 0	58 0 0
Zinc dust	85 0 0	—
Do. English	—	—
Zinc ashes, per cent. 70%	24 0 0	25 0 0
Official average price, Jan.		59 10 4½
Average spot price, Jan.		58 10 11¼

Lead.

Soft foreign (net)	52 2 6
English	53 5 0
Official average price, Jan.	47 7 1½
Average spot price, Jan.	47 2 2

Antimony.

English regulus	69 0 0
Chinese	66 0 0
Crude	61 0 0
Ore	Nominal.

Aluminium.

Virgin Metal 98/99— per ton.	170 0 0

Phosphor Bronze.

Ingots.	Per ton.
Alloy No. I. or II.	—
III., IV., or V.	—
IV. or VII	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
Castings.	Per lb.
I. or II.	—
III., IV. or V.	—
IV. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
,, Cored Bars	—
Delivery 2 Cwt. free to any town.	
10 per cent. Phosphor Copper price of best selected copper.	£40 above
15 per cent. Phosphor Copper price B.S.	£50 above
Phosphor Tin (5 per cent.) price of English Ingots.	£30 above

Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM.

***Chromium (Metallic).**	
98/99— purity, per lb. 6/6	— —
***Nickel.**	
In cubes, 98/99— purity per ton	£220 0 0
Nickel Silver.	per lb.
Ingots for raising	1/7 - 2/-
Ingots for Spoons and Forks	1/7 - 2/-
,, rolled to spoon size	1/10 - 2/3
***Tungsten Metal Powder.**	per lb.
96/98— purity	3/5
***Molybdenum Metal.**	
96/98— purity, per lb	—

	£ s. d.
***Cobalt Metal.**	
97— purity, per lb.	0 12 6
Quicksilver.	
75 lb. bottle	24 10 0
* Net, delivered Sheffield Works.	

Scrap Iron and Steel.

Cleveland.	s. d.	s. d.
Steel scrap, heavy melting	—	—
Iron scrap cast (cupola metal)	—	—
(London f.o.b.).		
Heavy steel	160	0
Light ,,	90	0
Heavy cast	150	0

Steel Scrap.	Per ton £ s. d.
Without Analysis—	
Heavy steel melting scrap	8 2 6
Steel planings, turnings and borings	7 5 0
Steel planings, turnings and borings mixed with wrought-iron or other material	7 0 0
Other classes of steel scrap, whether or not mixed	7 10 0
F.o.r. or in barge at nearest siding or wharf.	
With Analysis—	
Heavy steel melting scrap not over 0.04 per cent. p. and s.	8 10 0
Heavy steel melting scrap not over 0.05 per cent. p. and s.	8 10 0

Wrought-Iron Scrap.

	£ s. d.
(1) (a) W.I. plates and sections, not less than ¾ in. thick, reasonably clear of rivets, flanged ends, etc., suitable for shearing; cable scrap and chain scrap not less than ½ in. dia.	8 15 0
(b) Heavy W.I. scrap not less than ½ in. thick including horseshoes, rivets and bolts, and scrap therefrom	8 15 0
(c) W.I. scrap under ½ in. thick, and all W.I. scrap not included in classes 1, 2 and 3	8 15 0
(2) Mixed W.I. scrap	7 5 0
(3) Wrought-iron planings, turnings and borings mixed with steel or other materials	5 0 0
(4) W.I. planings, turnings and borings	5 17 6

Cast-Iron Scrap.

	£ s. d.
Heavy ord., broken, between 1½ cwt. and 10 cwt. each	7 5 0
Heavy machinery, broken between 1½ cwt. and 10 cwt. each	7 10 0
Cold blast, broken, between 1½ cwt., and 10 cwt.	9 5 0
Ingot mould, unbroken	8 10 0
Do. broken, between 5 cwt. and 2 tons each	8 15 0
Do. between 1½ cwt. and 5 cwt. each	9 0 0
Railway chairs, whole or broken for remelting	7 10 0
Heavy lumps, not exceeding 2 tons each	7 2 6
Light	6 15 0
Burnt, broken ready for cupola	6 0 0
Burnt fire bars	6 10 0
Turnings and borings, for iron and steel makers	7 0 0

Old Metal.

	£ s. d.
London—	
Copper (clean)	105 0 0
Brass (clean)	60 0 0
Lead (less usual draft)	41 0 0
Tea lead	39 10 0
Zinc	38 0 0
New aluminium cuttings	120 0 0
Braziery copper	92 0 0
Gunmetal	85 0 0
Hollow pewter	300 0 0
Shaped black pewter	190 0 0
(Above all d.d merchant's yard).	

Metallurgical Coke.

	£ s. d.
Durham and Northumberland—	
Blast furnace	2 10 6
Foundry	3 6 0
Lancs., Staffs., Yorks, Notts., Derbyshire, Lincolnshire and Midland Counties—	
Blast furnace	2 10 6
Foundry	3 6 0
F.o.t. at ovens.	